Edgar Littlefield, Instructor in Ceramic Art, Ohio State University, Columbus, Ohio, for the second consecutive year was awarded the $50 first prize for his pottery at the American Ceramic Society 1935 official exhibition of craft ceramics, the Fourth Annual Robineau Memorial Ceramic Exhibition held at the Syracuse Museum of Fine Arts, Syracuse, N. Y. The prize-winning pieces, a large plate with crackled white glaze and a vase of brilliant copper blue, are shown in this illustration.

For announcement of the other prize winners, three of which were members of the American Ceramic Society, see page 377.

Photo courtesy Syracuse Museum of Fine Arts.

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AMERICAN CERAMIC SOCIETY

Volume 14 NOVEMBER, 1935 Number 11

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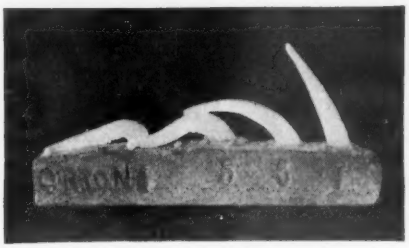

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EDITORIAL AND PAPERS

QUALITY CONTROL*

By F. M. Thorman

Abstract

Quality is that which identifies an article as outstanding in its field of use. Any institution expecting to remain in business today must accept the fact that quality is its biggest asset. Quality is the greatest factor in advertising and it is constantly before us in newspapers and magazines but the subject itself, with reference to maintenance methods, is seldom mentioned in any literature. This paper defines quality, points out the need for it, and offers a broad plan of its maintenance in the ceramic industry.

Quality Characterized and Its Value

Quality is that which identifies an article as outstanding in its field of use. We think of it as a measure of goodness in a product. It is the characteristic which distinguishes between competitive brands of the same type of product. As consumers, the one thing uppermost in our minds is quality. It is natural that in every purchase, no matter how small, we seek the best quality obtainable at the cost we have to pay. Quality is a subject constantly emphasized in advertising and sales literature and while the word itself may not appear, the idea is inferred in every advertisement we read.

Present-day merchandising methods result in a quick classification of the quality of a product. A new commodity may become firmly entrenched in a very few months and enjoy wonderful demand, bringing a rich return to its sponsors. Likewise complete failure may result even with the best efforts of merchandising. Quality, therefore, commands by far the greatest amount of attention in the merchandising of any product.

Never before has quality been so important. In this day of codes and bettered ethics, the merchandiser can claim only one advantage and that is quality. Almost any manufacturer or distributor can give excellent service, so merchandising efforts must naturally be concentrated on quality.

There should be no argument with the statement that any institution expecting to remain in business today must accept the fact that quality is its biggest asset. It is true, however, that there always has been and still is a tendency for some managements to take quality too much for granted. This is perhaps due to the fact that some of the other measurements of successful operation such as costs, harmonious labor relations, etc., are more quickly apparent to management than the results of quality and consequently receive more attention. The cost of inadequate quality is not so quickly measurable or judged as some of these other things.

Trade magazines are full of excellent help on costs, inventories, labor, merchandising, etc., but

* Presented at the second annual convention of the Ceramic Association of New York, Alfred, N. Y., June 7, 1935.

Received September 28, 1935.

one seldom sees anything dealing directly with quality and its control or maintenance. Technical publications carry a wealth of guidance in new processes and improved methods but everything is premised on the assumption of an exact manufacturing procedure. This is taken for granted and little is said about the actual control of the process or procedure. I have been able to find but two books dealing only with quality. A few years ago, the Department of Manufacture of the Chamber of Commerce of the United States prepared a booklet entitled, Foremanship, dealing with the training of foremen and key men in industry. There is a list of 124 subjects suitable for foreman training meetings in that booklet and in not one of them does the word quality appear. The two subjects coming closest to quality are "The Foreman and Inspection" and "Improving Workmanship."

Quality simply can not be taken for granted by management. It must receive constant attention and be jealously guarded. This is particularly true in the cases of products which have outstanding quality reputations. When a product becomes a standard in its class it also becomes a target for its aggressive competitors. It becomes increasingly difficult for a leading product in any field to maintain its lead. The sponsors of a successful product who are content to sit back and reap the benefits of consumer acceptance are doomed to quick disappointment. Never was the quality of a product so high that it could not be equalled or surpassed. Alert, progressive management recognizes the need for constant quality vigilance and systematic research, the first to insure maintenance of manufacturing standards and the second to provide improvements so as to keep the lead.

Loyalty to a product on the part of its sponsors, of course, is a very necessary thing. Too much loyalty, however, may keep the sponsor in ignorance as to just how good the competitive products are. We must never be satisfied that our product is the best even though every indication and method of measurement points that way. A little uncertainty is often best because it keeps us constantly on guard against a surprise attack.

General Plan for Quality Control

I have attempted to revive some thought of the importance of quality and why the maintenance of quality is so important in any industry or in any field of endeavor. A general plan of quality control is now presented which will apply to all branches of the ceramic industry. In fact, the principles laid down for this plan should apply to any kind of manufacturing.

First, the management of a concern must let it be known that high quality of its products is a policy. G. S. Radford, in his book, The Control of Quality in Manufacturing, says "Without the strong desire for quality, beginning at the very top of the organization, there is little chance for securing quality. Thus it is one of the prime responsibilities of ownership and management." The management must see that there is a clear understanding of the policy by each employee. The policy must constantly be restated to avoid the possibility of its being side-tracked occasionally in favor of doing a job in what appears to be an easier way without quality restrictions.

The next step is to place the responsibility for quality maintenance, which must be borne entirely by the production department. Those persons in any organization, large or small, whose duty it is to manufacture and ship, must carry the full responsibility for the quality of the output. Most plants of average size in the ceramic industry have some sort of an inspection staff, small or extensive as required, which is more or less separate from actual production. That inspection staff can be held responsible for such inspection as is required to measure quality but it can not be held responsible for the quality of the products that are shipped. Division of responsibility or relief to the production department in any way for the responsibility simply invites trouble. Unless the production people have to carry the full responsibility for quality, there is bound to be the well-known "passing of the buck" when complaints develop. Quoting again from Mr. Radford's book, "The inspection department's relation to the whole organization is judicial rather than creative. It is responsible to the management for detecting failures in quality and, in that sense, it bears a very heavy responsibility for the maintenance of standards. It does not manufacture, however, and therefore when poor work is produced the production department can not usually shift the blame to the inspection department. The production department should be made to realize that it is itself responsible for the quality of its product—it makes the work

right or it makes it wrong. Both departments then bear a definite responsibility to the management for quality, but independently and in different ways."

The third step is the establishment of product and process specifications. It is unfair to any individual or group of workmen to be held responsible for the quality of the article or articles being produced unless they have a clear understanding of the requirements to be met; and the only fair way to handle this phase of the job is to have written specifications. I am a firm believer in putting things down in black and white. When this is done there can be no alibi offered when something goes wrong. Such a system protects both the worker and the management. It is not so easy to provide written procedure for processes as it is to set up written specifications for the finished article. The most elaborate directions for operating an automobile, placed in the hands of a person who has never driven a car, can not be relied upon to make that person a satisfactory driver. What can not be written into any set of directions are *art* and *experience*. Both are invaluable to the performance of a job in the best possible manner. The written direction, however, provides an excellent foundation or starting point for any job and is especially valuable to the new man. Written specifications for processes prevent misunderstandings and confusion just as finished product specifications in the same form eliminate alibis for shipment of substandard goods.

Fourth in the establishment of quality control is setting up adequate inspection. The most thorough job of establishing quality standards and process procedure is wasted unless there is a method for measuring performance against these standards. Management needs this. A testing department provides the best yardstick for the purpose. We all recognize the absolute need for accounting in any business. It is something indispensable. We know the valuable part that auditing plays in accounting. The testing department in reality is the quality auditing branch of the business. The inspection and testing needs of different industries and different plants in the same industry vary a great deal, but the principles governing the work are the same everywhere. To be of real value, the testing department must be divorced from actual production. The plant inspector or inspection staff should function directly under the plant manager who carries the responsibility for all phases of operation. Any system of inspection not founded on this principle is to a large extent a waste of money and effort.

Details of Executing Quality Control Plan

Having established the value of quality control and outlined a general plan for its set-up in any industry, some of the details in the execution of the plan will be discussed.

Product and process specifications should be established and maintained through the inspection department. To be effective, such specifications must be kept up to date at all times. It is better to be without written specifications than to have obsolete or even partially obsolete specifications in existence. Specifications should be simple, clear, and as brief as possible. All persons responsible for the execution of a particular specification should have a copy of it. The master copy retained by the inspection department should bear the signatures of all persons to whom copies were issued. These signatures constitute receipts for the specifications and indicate acceptance of the instructions. This simple precaution sometimes saves much argument.

The personnel of an inspection department must possess some definite qualifications. It goes without saying, of course, that the various members must have the proper educational background. Naturally the educational requirements will vary with the different kinds of work. It is a fact, however, that knowledge and educational training are not the most important qualifications of a man on inspection work. The characteristics of judgment, honesty, and personality are very important. Any one who is really successful in a judicial capacity (and inspection work is certainly a judicial function) must have judgment, tact, and personality. Not one of us likes to receive criticism, but we all know that there is a great deal of difference in the way it can be handed out. It is only natural that we respond quickly and more cheerfully when we respect the source.

Probably there is no better training school in industry than in the inspection department. Inspectors and testers in industries associated with ceramics have an excellent opportunity to study all phases of operation. It is my belief that no one should be hired for this work who does not possess the qualifications of a good operating man. The knowledge and experience gained from

inspection and testing work, or quality control work (as I prefer to call it) is of immense value to the production man. Why not therefore use the quality control department as your training school?

Quality control through inspection and testing should provide a continuous, systematic check throughout all processes and up to and including loading or preparation for shipment of the finished product. The most successful control system completely covers the operation. The administration of such a system generally centers in the plant laboratory. Here is maintained the necessary records and reports in addition to those facilities of testing which can not be transported about the plant. Elaborate records and reports are usually not necessary. Reports made for the guidance of the operators and to keep the management adequately informed should be simple and free from unnecessary data. This kind of report is certain to receive more attention than a very detailed report.

The quality control department should have available for immediate reference at all times complete, up-to-date specifications, quality standards, packing and loading procedure, and the detailed requirements of each individual customer. There are many manufacturers who produce a single article made to one standard, but even these concerns have customers requiring some sort of special attention. It is advisable to have a record of these special requirements in the quality control department. All customer orders should be routed through this department and proper notations made on them as to specifications and special attention that may be required.

The use of correct raw materials is also very important in the maintenance of quality. Everything used in processes and products should be purchased on specification and each shipment should be checked by the control department before use. I wonder how many concerns who purchase raw materials that are packed in bags, bales, boxes, and other containers actually weigh many of the packages upon arrival? This is good practice, and it usually will be found that the expense of doing this is more than justified. Not only are occasional shortages in weight detected, but there is more assurance that correct amounts of materials are being used in cases where proportioning is done by adding so many bags or other units to the batch.

Employees should be kept thoroughly familiar with the company's advertising literature. More interest is taken in quality by the employees when they are kept informed about what the management is claiming for the products. Along this same line, some effort should be made to acquaint employees with the correct use of the company's products. This is especially valuable in the case of those manufacturers serving the building industry and whose products are subject to further treatment and handling on the job before becoming parts of the final structure. I fully realize how difficult it is to impart this knowledge to every employee, but it can be done for those filling the key positions.

The word complaint always suggests one thing, which is dissatisfaction. One of the principal functions of quality control is to minimize justified complaints, traceable to off-quality products, by preventing the manufacture and shipment of such products. Complaints, however, can be a valuable asset to any institution if properly utilized. In the first place, it pays to attach considerable importance to the individual complaint. Regardless of its cause, the responsibility for it or its possible cost, the fact remains that a customer is not satisfied. Of first importance then is a speedy and thorough investigation of the complaint, followed by prompt disposition of it. If the manufacturer is responsible, then a satisfactory adjustment should be made. If the manufacturer is not responsible, he should nevertheless see that the real cause is determined and that the customer is convinced as to this cause. In the proper handling of a complaint, the company has an opportunity of selling the customer on its service.

Justified complaints or those caused by some product defect can point the way to product and process improvement. Such complaints to be of the greatest value must come to the attention of all concerned. Many companies make it a practice to enter all complaints formally and require an answer from the manufacturing department, showing the cause for the trouble, persons responsible for shipment of the inferior article, and corrective measures taken to prevent similar complaints in the future. It is possible also to use complaints to measure the performance of a plant, a department, or an individual employee. There is much to be gained from a proper study of trouble in the form of complaints.

Much time could be given to the reasons for failure in quality control. There might be many contributing factors such as poor equipment, off-quality raw materials, inadequate personnel, etc., but proper management could have prevented any or all of these reasons. Failure can result only from improper organization control.

Adequate organization control or management for the production of quality products is the same as for all other phases of operation. First, there must be a clear understanding of the management's requirements by all concerned. This is of fundamental importance. The worker must know his job and what is expected of him. The average worker wants to do his work right and for the best interests of his employer. Failure on the part of the employee often occurs because his immediate superior does not make the requirements entirely clear. Placing responsibility, backed by necessary authority, comes next, followed by an adequate system of check testing and inspection. These are the principal factors in the control of quality.

Equipment, processes, and materials are all subservient to men and management; therefore, if our desire for perfection in quality is sufficiently intense and is backed by an inflexible determination to attain it, we shall not fail to reach our goal.

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EFFECT OF INSULATION ON THE SILICA REFRACTORIES OF AN OPEN-HEARTH STEEL FURNACE ROOF*

BY LEWIS B. MILLER

ABSTRACT

The use of insulation on an open-hearth steel furnace roof is desirable because of the large possible monetary savings involved through reduction in heat losses. The deciding factor in the use of insulation, however, is of a ceramic nature. It is the ability of the silica refractory to withstand the severe conditions imposed upon it by operating conditions which determines whether or not insulation may be used on the furnace crown. From the above considerations, the factors affecting the life and stability of the silica refractory of an open-hearth furnace crown are analyzed and found to be two, chemical and physical. (1) The physical factor is temperature. Silica refractories taken from open-hearth furnace crowns indicate three zones to have been formed due to temperature effects. The zone nearest the interior of the furnace, which is subjected to the highest temperature, is found by petrographic analysis to consist predominantly of cristobalite. The middle zone is predominantly tridymite and the outer one, quartz. (2) The chemical factor is the formation of iron silicates from the metallic charge and the silica of the refractory and the effect of these silicates upon the silica refractory. The formation and properties of the iron silicates are viewed in the light of phase-rule knowledge of the system $FeO–SiO_2$. It is found that the effect of the iron-silicate liquid formed is less destructive upon the refractory in an insulated than in an uninsulated furnace. From consideration of the several factors involved it is concluded that insulating an open-hearth furnace crown will prolong the life of the silica refractory.

I. Introduction

The deciding factor in the use of insulation on an open-hearth furnace roof is the ability of the silica refractory of the roof to withstand the severe conditions imposed upon it by the operating conditions of the furnace.

It is well known that the temperature differential between the operating temperature of an open-hearth furnace and the fusion temperature of the silica refractory composing the roof of the furnace is relatively small.[1] The silica refractory is therefore subjected to temperatures at which physical and chemical changes occur readily.

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received March 29, 1935.

[1] (*a*) E. F. Entwhistle, "Insulation of Open-Hearth Furnaces," *Amer. Iron and Steel Inst. Year Book*, pp. 166–77, 1933.

(*b*) Minutes of the 17th Conference of the Open-Hearth Comm., Amer. Inst. Mining and Met. Engineers, Pittsburgh, Pa., June, 1934.

(*c*) G. K. Burgess, "Temperature Measurements in Bessemer and Open-Hearth Practice," *Bur. Stand. Tech. Paper*, No. 91 (1917).

Much attention has been given lately to the subject of the insulation of open-hearth steel furnaces.[1a] Among the reasons for this interest and activity are the following: (1) lower heat loss reflected in lower fuel consumption; (2) lower gas velocity through the furnace, through the checker work, and up the stack; (3) smaller air requirement in proportion to the reduction in fuel consumption, and (4) smaller temperature drop between heats.

A number of silica brick was obtained from the roofs of two open-hearth furnaces after these furnaces had passed through a normal operating campaign. One of these furnaces was uninsulated; the other had had the roof insulated

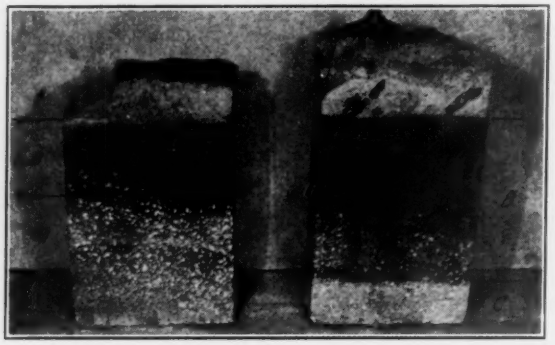

FIG. 1.—Silica refractories taken from an uninsulated open-hearth furnace (left) and from an insulated open-hearth furnace (right) after normal operating campaigns. Note particularly the small cracks in the refractory from the uninsulated furnace (left) in zone C near the junction of B. Note also the greater breadth of zone B in the refractory from the insulated furnace (right) and the more gradual gradation from zones B to C.

by two inches of Zonolite[2] base-insulating cement. The samples of refractory were obtained from corresponding positions near the center of the roof.

One brick was selected from the insulated and one from the uninsulated furnace, sawed in half lengthwise (see Fig. 1), and examined in detail by visual, chemical, and petrographic methods.

II. Silica Refractories and Their Reactions at High Temperatures

(1) Effect of High Temperatures

Under the operating conditions in an open-hearth furnace, the two major sources of change to which the silica refractories are subjected are high temperature and the chemical action of iron oxide. Quartz is stable from low temperatures up to 1598°F (870°C). Between 1598°F and 2678°F (1470°C), tridymite is the stable phase; from 2678°F to its melting point at 3142°F

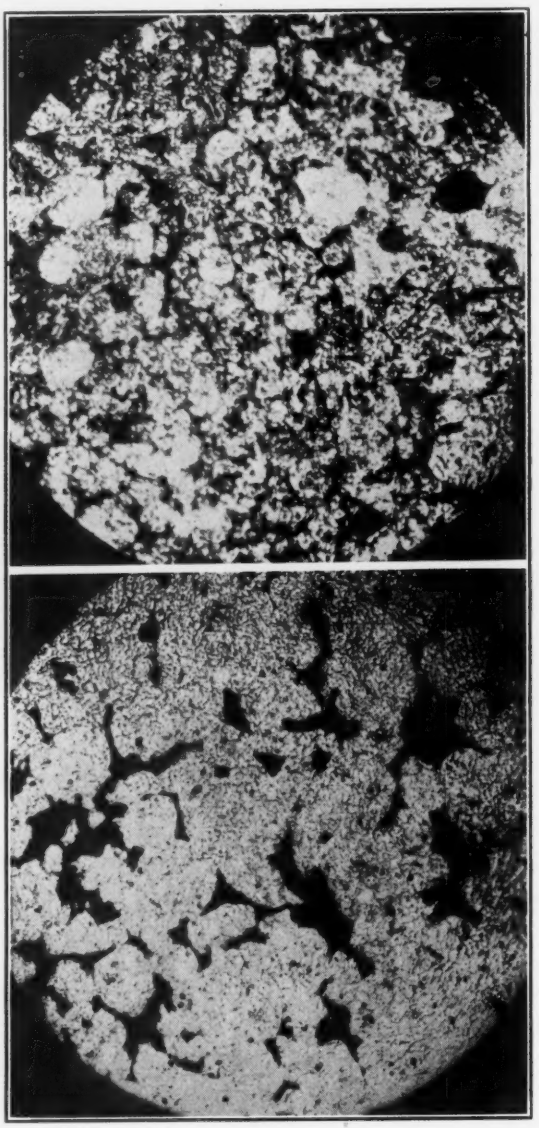

FIG. 2 (above).—Photomicrograph of a thin section of zone A (see Fig. 1) of a silica refractory taken from either an uninsulated or an insulated open-hearth furnace after a normal operating campaign (crossed nicols, 75×). The crystalline material consists of cristobalite; zone A is the portion of the refractory subjected to the highest temperatures during furnace operation.

FIG. 3 (below).—Photomicrograph of a thin section typical of zone A (see Fig. 1) of a silica refractory taken from either an uninsulated or insulated open-hearth furnace after a normal operating campaign (75×). The light-colored material is cristobalite. The large dark spots between the cristobalite crystals represent intrusion of ferrous silicate drawn into the pore spaces of the refractory by capillarity.

[2] Zonolite is the trade name of an expanded mica extensively used in the manufacture of insulating cements.

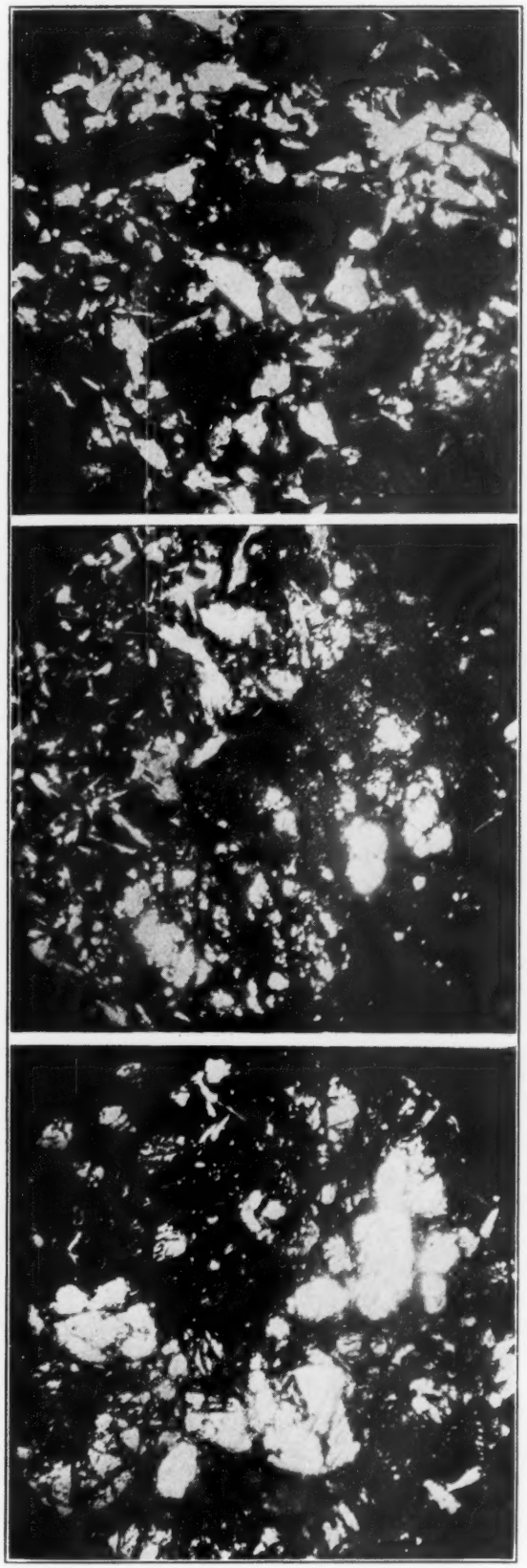

FIG. 4 (top).—Photomicrograph of a thin section taken from the part of zone B (see Fig. 1), which closely adjoins zone A, of a silica refractory, typical of either an uninsulated or an insulated open-hearth furnace after normal operating campaign (crossed nicols, 75×). The crystalline material is tridymite; note wedge-shaped crystals and occurrence of twinning.

FIG. 5 (center).—Photomicrograph of a thin section taken from the part of zone B (see Fig. 1), which adjoins zone C, of a silica refractory typical of either an uninsulated or an insulated open-hearth furnace after a normal operating campaign (crossed nicols, 75×). The crystalline material is a mixture of quartz and tridymite. The elongated, wedge-shaped crystals are tridymite. The more rounded particles are quartz. Note that tridymite predominates over quartz.

FIG. 6 (bottom).—Photomicrograph of a thin section taken from zone C (see Fig. 1) of a silica refractory, typical of either an uninsulated or an insulated open-hearth furnace after a normal operating campaign (crossed nicols, 75×). The crystalline material is predominantly quartz. A few wedge-shaped crystals of tridymite are present. This section is from the coolest portion of the silica refractory during furnace operation.

(1728°C), cristobalite is stable. When silica is held continuously in any one of these temperature ranges, the crystalline type stable in that range will be slowly formed from either of the other two crystalline types present.

Silica brick, as marketed, consists of quartz largely converted to tridymite or cristobalite or both. Conversion to the modifications stable at higher temperatures is desirable, as far as it is economically possible before placing the refractory in service, because the conversion involves volume changes.

The operating temperatures in an open-hearth furnace are above the tridymite-cristobalite inversion temperature of 2678°F. It would be expected therefore that the portion of the refractory adjacent to the interior of the furnace would consist of cristobalite and the portion adjacent to the exterior of the furnace would contain quartz, while the intermediate portion might consist of tridymite. Figures 2 to 6 show that several crystalline forms of silica occur in the various zones as was anticipated.

(2) Effect of Iron Oxide

Figure 7 is the phase-rule diagram representing the system, ferrous oxide–silica.[3]

During the progress of a heat, iron oxide is deposited upon the inner surface of the silica roof. At the operating temperature of the furnace, this oxide, which is partly ferrous and

[3] N. L. Bowen and J. F. Schairer, "The System Ferrous Oxide–Silica," *Amer. Jour. Sci.*, **24** [9] 177–213 (1933).

partly ferric, is molten. It therefore penetrates into the pores of the silica brick and reacts chemically with it to form a ferrous-ferric silicate liquid. Since silica is present in excess, the iron oxide will continue to combine with it until the liquid is saturated with silica.

Since the ternary system, FeO–Fe_2O_3–SiO_2, has not been worked out completely, it will not be possible to make a final statement about these reactions, but a good indication of their probable course can be had from the system FeO–SiO_2. The liquid will react with silica until a composition, represented approximately by the point X (Fig. 7), is reached. This iron-silicate liquid is sufficiently low in viscosity to be drawn readily into the porous refractory by capillarity. As the liquid of composition X penetrates into the refractory, cooler portions of the refractory are encountered. If equilibrium is attained, silica in the form of cristobalite begins to freeze out and deposit in the pores of the refractory. The diagram (Fig. 7) shows that the freezing temperature falls rapidly with diminishing silica, along the line, CD. The remaining liquid, which has become richer in FeO and so melts at a lower temperature, penetrates the refractory until all of it has solidified, continuing to deposit silica, first as cristobalite and at lower temperatures as tridymite as freezing progresses. The final composition to solidify is represented by the point, E.

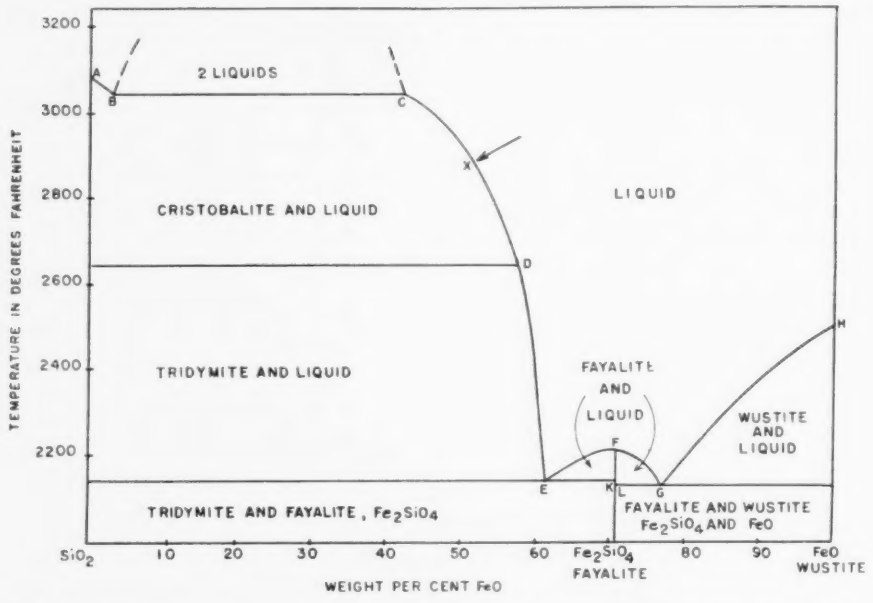

FIG. 7.—Equilibrium diagram of the system FeO–SiO_2 (after Bowen and Schairer).

Thus the liquid, containing dissolved silica in combination with iron oxide, penetrates into the refractory and is redeposited as silica (cristobalite and tridymite) and also as magnetite, fayalite, and siliceous glass. By this process, the refractory is rendered more dense by the filling of its pores. It is only rarely and in cases where overheating occurs, up to the line BC in Fig. 7, that the refractory is melted and drips into the furnace. Experience has shown that a well-managed open-hearth roof loses only about 0.03 inch in thickness with each heat.[4]

The steep slope of the liquidus curve between C and E is advantageous in that it indicates that a decided increase in temperature permits a given amount of iron oxide to dissolve only a small additional amount of silica. If the reverse were true and the slope were more mild between C and E, iron oxide might be much more effective in melting down silica refractories.

III. Effect of Insulation on the Refractory under Operating Conditions

Figure 1 is a photograph of two silica brick taken from the roofs of open-hearth furnaces after normal operating campaigns. The uninsulated brick is at the left and the insulated brick, at the right. Zone A, at the top, is the portion subjected to the highest temperatures and consists essentially of cristobalite crystals, with a small amount of vitreous silica and some ferrous silicate formed by chemical reaction of the silica and iron oxide. The almost complete conversion of silica to cristobalite (see Figs. 2 and 3) indicates that this portion of the refractory was consistently above a temperature of 2678°F (the inversion temperature of cristobalite and tridymite).

[4] Personal communication to the writer

The middle zone (zone B) consists essentially of cristobalite and tridymite (Figs. 4 and 5) and therefore must have been subjected to temperatures between 1598°F and 2678°F the greater part of the time. Zone C (Fig. 6) consists principally of unchanged cristobalite and quartz and must therefore have been exposed to temperatures below 1598°F for the greater part of the time.

There is a gradual variation in the character of the tridymite crystals through zone B. Thus the portion of zone B adjacent to zone A shows large, well-developed crystals of tridymite with occasional evidence of some inversion to cristobalite; the center contains well-developed tridymite crystals as the only form of pure silica (there is also a dark-colored solidification product of a ferrous silicate liquid between the tridymite grains), and adjacent to zone C, the tridymite crystals are relatively poorly developed. Occasional remains of partially converted quartz are found, particularly in some of the larger grog particles.

Zone C shows a somewhat similar condition. Near zone B, considerably more tridymite is noted than in the portions of zone C nearer the furnace exterior, although the amount of tridymite present in any case is never large.

Zone A appears to be reasonably homogeneous throughout.

In zone C, almost at the junction between B and C, there are several short cracks. The line of demarcation between B and C in the brick on the left is very sharp. The cracks noted are due to the fact that the expansion and contraction of zones B and C, upon heating and cooling, are different, owing to penetration of the iron silicate liquid. Therefore during the heating and cooling which occurs during and between heats in the furnace, cracks develop near the junction of these two sharply demarked zones. Sometimes these cracks develop to the point where the two halves of the brick separate and the hotter portion (upper portion in Fig. 1) falls into the furnace.

IV. Comparison of Brick from the Insulated and Uninsulated Furnaces

Zone A (the cristobalite-containing portion) is slightly thicker in the insulated than in the uninsulated furnace brick but not essentially different. Zone B, however, is very wide in the brick from the insulated roof and includes the greater portion of the brick. Zone C is very narrow and includes only a thin section of the coolest part of the insulated brick. It will be noted, moreover, that the line of demarcation between zones B and C is much less pronounced. Instead of the sharp transition from B to C, as noted in the brick from the uninsulated furnace, this brick shows a gradual transition from zones B to C. This is important, for it indicates that the sudden change from zone B to that of the unchanged refractory (zone C) which caused cracking in the case of the uninsulated furnace brick (Fig. 1, left) is changed here to a gradual gradation (Fig. 1, right). This does not set up sharp stresses producing cracking. Therefore, in the insulated furnace brick, there is a greater stability and resistance to disintegration and cracking during heating and cooling.

In the uninsulated furnace, the drop in temperature from the inside of the furnace to the outside is large; hence, the temperature gradient through the refractory is high. The dark-colored molten iron silicates formed at the surface of the brick can not penetrate very far into the brick before they cool and solidify, as is indicated by the relatively narrow zone B on the brick to the left. Because of the high temperature gradient through the brick, the depth of penetration of the molten iron silicate ends abruptly as indicated by the sharp line of demarcation. The two portions, B and C, of the refractory differ in physical properties and are thus subject to cracking during heating and cooling.

With the brick from the insulated furnace, on the other hand, the surface of the brick nearest the interior of the furnace has been at the same temperature as in the case of the uninsulated furnace, and this portion of the two specimens is similar. The outer side of the brick (C) has been kept at a considerably higher temperature in the case of the insulated brick. The temperature gradient through it, therefore, is lower, than in the case of the uninsulated brick, and the average temperature through the insulated furnace brick is higher. The molten iron oxides penetrate more deeply, making zone B wider and the transition from zone B to zone C more gradual. The stresses set up in the brick, due to the temperature gradient and the iron silicate penetration, are smaller, and there is a lesser tendency toward cracking in the case of the insulated refractory.

Because of the higher average temperature through the insulated brick, a larger portion of it is converted to the forms of silica stable at high temperatures, tridymite and cristobalite, which is an additional advantage. No doubt, the presence of ferrous-silicate liquid in the greater portion of the refractory likewise functions to catalyze the inversion to tridymite and cristobalite.

It is clear that a refractory from a properly operated, insulated open-hearth furnace has been brought to a more stable crystalline state with respect to high temperatures and is subject to smaller stresses than is the case with an uninsulated furnace. The refractory from an insulated furnace is not, as sometimes assumed, subjected to more severe conditions than from an uninsulated furnace (when both furnaces are properly operated); indeed, the reverse is the case. Therefore, the refractory of an insulated furnace will last longer than will the refractory of an uninsulated furnace.

One of the principal sources of trouble in the use of silica refractories is their change of volume during high-low inversions on heating and cooling during intermittent operation. The high-low inversions of tridymite involve a much smaller volume change than the corresponding inversions of either quartz or cristobalite.[5] To have a greater portion of the refractory consist of tridymite would, therefore, tend toward constancy of volume during its use in the furnace and, from this standpoint, would be advantageous.

[5] R. B. Sosman, The Properties of Silica, Chemical Catalogue Co., p. 813.

V. Conclusions

Insulation tends to lengthen the life of a silica roof and to increase its stability under general operating conditions. The advantages which accrue, in addition to the reduction of heat losses, are as follows:

(1) In the insulated furnace, a larger proportion of the refractory is converted to the desirable crystalline types of silica stable at high temperatures, tridymite and cristobalite.

(2) In the refractory of an insulated furnace, penetration of molten iron silicate into the pores of the silica refractory of the roof does not set up as high stresses as it does in the refractory from an uninsulated furnace, where it sometimes leads to cracking.

(3) The temperature gradient through the silica refractory of an insulated open-hearth furnace roof is lower than in the case of an uninsulated furnace. The stresses, due to temperature difference, are less pronounced therefore in the refractory of an insulated furnace.

All of these factors tend to greater stability and longer life in the refractory.

Acknowledgment

The writer desires to express appreciation to the Granite City Steel Co., St. Louis, Mo., for furnishing the specimens of silica refractory and to R. B. Sosman of the Research Laboratory, United States Steel Corporation, for advice and suggestions during the course of the research and preparation of this manuscript.

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ENAMEL THICKNESS GAUGE*

By M. A. Rusher

The importance of thickness control of materials applied to metal as protective or decorative films is becoming generally recognized. Heretofore available methods of measurement have marred or destroyed the film, or the procedure of measuring the difference between the final overall and the initial metal thickness was too cumbersome. The principle of the electric gauge,[1] which has been found suitable in the field of mechanical measurements for improving the accuracy of machine parts, has been applied to this new field of measurement. This has made it possible not only to measure the thickness of enamel, paint, or other nonmagnetic coatings on steel but to measure it so quickly and easily that the thickness of these coatings can be readily controlled.

In most fields of thickness measurement, it is possible to make contact with two opposite surfaces or with two points on surfaces bearing a definite relation to each other. This does not apply to measurements of thickness of vitreous enamel or of other coatings on steel since, at the time of the measurement, only one surface is exposed. For this reason, some have resorted to gauging methods which have punctured the film, but these methods can not be applied to vitreous enamel because of the hardness of the surface and they are not entirely satisfactory for other coatings since they destroy the continuity of the film. Other gauges are dependent upon the dielectric properties of the film to be measured and, in the case of paint films, give a reading which varies with the dryness of the coating.

The requirements to be met in a gauge for measuring the thickness of enamel or other coatings on steel are as follows: (1) A gauge should measure either vitreous enamel or lacquer (refrigerator cabinets are frequently made with vitreous enamel on the inside and lacquer on the outside). (2) It should not injure the surface where the measurement is made. (3) It should give an accuracy well within the tolerance obtainable in manufacture. (4) It should be portable so that it can be moved from place to place readily. (5) Measurements should require a minimum of time so that a number of measurements could be made, without slowing up production, on each piece measured to determine variations in thickness of enamel.

The enamel thickness gauge (Fig. 1) has been designed to meet the requirements listed above. This gauge consists of a gauge head and an indicating unit. When the gauge head is held directly on an enameled flat surface, the thickness of the enamel can be read from the instrument of the indicating unit. It is designed to operate from any 110-volt, 60-cycle lighting circuit.

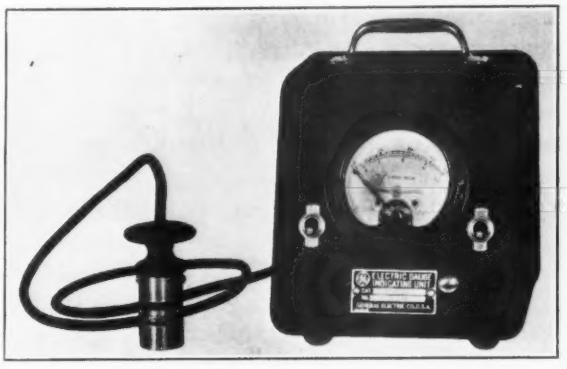

Fig. 1.

The enamel thickness gauge depends for its operation upon the magnetic circuit (indicated in Fig. 2) passing through the coil of the gauge head and through the sheet of steel directly under the enamel where the gauge head is placed. Since the greater part of the reluctance of this magnetic circuit is produced by the enamel or other nonmagnetic film being measured or by the equivalent air gap which separates the pole pieces in the gauge head from the sheet of steel, the indicating instrument shows directly the thickness of this material or of the air gap.

The indicating unit is readily adjustable for a given thickness range by adjusting the air gap in the magnetic circuit of the balancing coil until the indicating instrument reading corresponds to the known thickness of a sample of enamel or other nonmagnetic material under the gauge head.

* Received June 21, 1935.

[1] A. V. Mershon, "Precision Measurements of Mechanical Dimensions by Electrical Measuring Devices," *General Electric Rev.*, **35** [3] 139–44 (1932).

When thus adjusted, it will indicate the thickness of enamel on any flat surface in the same thickness range by simply holding the face of the gauge head in contact with that surface.

The size of the sheet measured is no limitation as long as a flat portion can be found slightly more than an inch in diameter. With this gauge, it is not necessary to confine measurements of thickness of large sheets of insulating materials to their edges since it is just as easy to measure at the middle. It has been found that there is often a bead around the edge of a flat enameled sheet which is much thicker than the average for the sheet. Such variations in the thickness of enamel on various parts of a sheet can be determined as fast as the gauge head can be moved from place to place.

Table I shows the variation in thickness of vitreous enamel on a number of sample sheets. These sheets were 9 inches long and measurements were made starting an inch from one end and then each inch up to one inch from the other end. Measurements were also made at one point each on the side and end beads. The variation from nominal thickness on these samples was as high as 20%, not counting the measurement made on the beads at the edges of the sheets. It has been found that the thickness of enamel can be controlled to a much closer tolerance than this would indicate. The control of thickness is one of the prime objects of a gauge of this kind.

The portability of this gauge is shown by the fact that it weighs but $7^1/_2$ pounds complete. Of this weight, the indicating unit comprises approximately 7 pounds and the gauge head, which is the only part held in the hand, weighs less than one-half pound. It can be readily moved to the work, thus saving much time and labor in moving parts to be measured.

All of the measurements given in Table I were taken with the gauge shown in Fig. 1 in approximately half an hour. This gives some idea of the short time required for such measurement. The readings on the first two samples were taken, using the scale with a range from 2 to 10 mils while the remainder were taken on the 10- to 50-mil scale. These gauges are not limited to these thickness ranges but can be designed for lower or higher ranges. The use of two scales on the indicating instrument doubles the range covered by a single gauge. This makes it possible to gauge the thickness of a priming coat with one

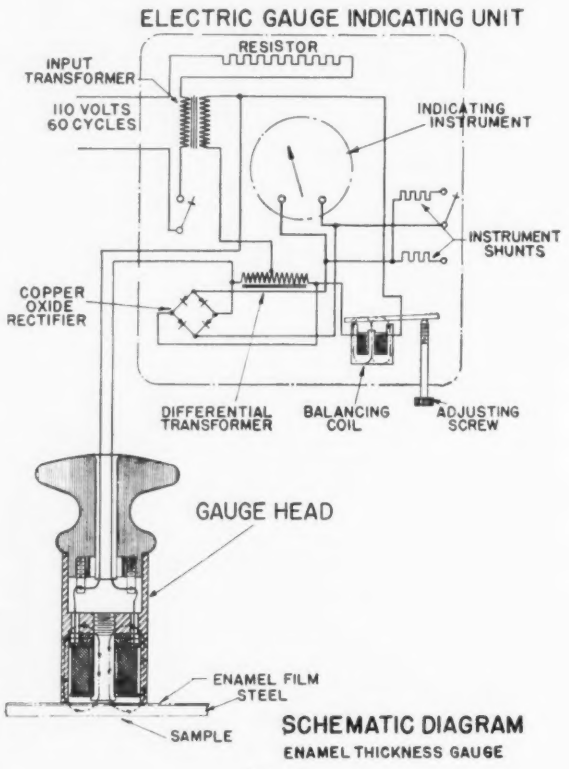

FIG. 2.

TABLE I

Sample No.	Thickness nominal	Thickness in mils, Location 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	Side bead	End bead	Variation from nominal thickness* (%)
1	3.5	4	4.2	3.1	3	3.3	3.1	3.4	3.2	4	4.5	20
2	7.6	8.8	8	8.5	8.6	7.5	7.4	7.5	7.4	8.5	10	16
3	10	10.5	10	10	10	10	10	10	10.5	11	12	5
4	13	15	13	12.5	12.5	11.5	12	12	12.5	14	18	15
5	16	17	16.5	16	15.5	15	15.5	16	16	18	21	6
6	20	20	18	16.5	17	17.5	18.5	19	20	22	25	17.5
7	23	24	22.5	21	20.5	20.5	21	22	23	25	31	11
8	27	27	24.5	23	23	24	24	26	28	27	32	15
9	32	35.5	32	30	29	29	29.5	31	32	35	41	11
10	37	39	36	34.5	35	34.5	36	37.5	38	42	44	7
11	43	46	42	38	37.5	37.5	39	41	44	45	50	13

* Side and end beads not included in these values.

scale and the final coat with the other scale of the same instrument.

The advantages secured by thickness control are (*a*) economy of material, (*b*) a rational basis for establishing costs, (*c*) uniformity of adherence to the metal, and (*d*) reduction in "chipping" losses due to overthickness. Any one of these advantages is sufficient to make control of thickness desirable and profitable.

This gauge is adapted not only to the measurement of the thickness of vitreous enamel and of paint and lacquer films on steel but can also be used for measuring the thickness of sheets of glass, celluloid, mica, or other insulating materials which can be laid on a flat sheet of iron or steel. The advantage of being able to measure the thickness of these materials quickly at the middle of the sheet as well as near the edges is apparent. It can also be used for measuring the thickness of plating of nonmagnetic metals on steel, although this application requires some modifications in design because of the very thin layers usually applied.

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ONE COVER-COAT ENAMEL FINISHES*

By F. R. Porter and G. L. Bryant

Abstract

Research has been conducted to reduce the thickness of enamel coatings in order to lessen chipping and materials cost. A single cover-coat system of reduced thickness has been evolved and a summary is presented of the necessary steps in this system.

I. Introduction

There has been a decided movement recently among the manufacturers and users of frit to reduce the quantity of enamel required per unit area in order to secure an acceptable exterior white finish. Two things are chiefly responsible for this activity, *viz.*, the reduction in chipping that apparently would result from thinner coatings and the reduction in cost of materials. The chief disadvantage of a porcelain-enamel finish is its tendency to chip from strain, due to design, assembly, and impact. Chipping occurring in transit alone represents a large sum of money and undermines the reputation of the manufacturer. Although thin enamel coatings would not eliminate chipping, they would greatly reduce it, and a satisfactory thin cover coat may be obtained with one spraying and one firing operation, resulting in a definite reduction in cost.

This trend toward thinner coatings has also involved the producers of enameling iron. A grade of iron is required that will give a finish as free as possible from black specks due to reboiling and other defects which have been considered more or less inherent in enameling iron. A great deal of industrial research work on this problem has been carried out by steel companies and research institutions during the past three or four years and, while it is not entirely solved, iron can be obtained in production quantities which is remarkably free from black specking. Some nonreboiling iron has been produced in sizable quantities, but the technique of manufacture or development is not sufficiently advanced at the present time to allow its production on a plant scale. The writers can think of no greater benefit to the enameling industry at this time than a nonreboiling iron.

The frit manufacturer's contribution to this single cover-coat system is the ultra- or super-opaque frit. More than a year ago the best commercial white cover-coat frit for steel had a reflectance of approximately 70.0% (Priest-Lange apparatus) at 2 ounces (56 grams) per square foot application. At the present time, similar frits with similar mill additions are available that produce an enamel which, when milled to normal fineness, gives the same reflectance at $1^1/_2$ ounces (42 grams) per square foot application. This increase in opacity has been the important contribution to obtaining a single cover-coat finish.

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

Without this, it would have been impossible to obtain a finish of satisfactory reflectance and sufficiently low in unit weight to permit its practical application.

Practically none of the frits of the super-opaque variety at present produces as attractive finishes as the frits of ordinary opaqueness; there is less gloss and the waviness or "orange peel" is more pronounced than with the commercial frits of a year or two ago. The working range or ability to stand abuse during application is also likely to be found lacking with the super-opaque frits.

The frit user has contributed by (1) increasing opacity by altered mill-room practice and (2) improved processing of enamel parts, including (*a*) pickling, (*b*) ground coating, (*c*) cover-coat application control, (*d*) drying, and (*e*) handling.

II. Increasing Opacity by Altered Mill-Room Practice

Porter and Holscher[1] have shown that finer grinding of enamel slips increases the opacity. This practice has been followed in the enameling shop of this Company for the past year. The practice has been to mill to a fineness of $^1/_2$ to 1% on a 325-mesh sieve using a wet sample. The increase in reflectance is approximately 5% and represents an enamel materials reduction of about 15%.

Different frits behave differently as to increase in opacity with fine grinding. In general, the increase is more with the less opaque frits.

It has also been found that by adding the opacifier (tin oxide) near the end of the milling cycle rather than at the time the mill is charged, the opacity is increased by about $1^1/_2$%. Likewise, the use of the correct clay in the mill charge further increases the opacity by some 3 or 4%. Therefore, by taking advantage of the most suitable frit, the most economical percentage of opacifier, fine milling, adding opacifier near the end of the milling, and using a suitable clay, it has been found entirely feasible to obtain in production an enamel finish having a reflectivity of 70% at an application of $1^1/_4$ ounces per square foot.

It should be pointed out that more difficulty will be experienced in obtaining color matching with these finishes of low-weight application because of a comparatively large change in opacity with a small variation in enamel weight. This is not generally true at higher weight applications where the weight-reflectance curve tends to "flatten out."

III. Improved Processing

(1) Pickling

It has been found essential to keep closer control of the pickling process. Ware going to the ground-coat dippers must be clean and present as uniform a surface as possible to insure a uniform ground coat pick-up. The nickel strike is coming into prominence as a means of obtaining a more uniform ground-coat finish. A satisfactory nickel strike bath requires continual attention.

(2) Ground Coating

Closer attention to details is required in the ground-coat process. The enamel must be kept clean and uniform. Drain lines, particularly those originating at perforations, must be kept at a minimum as they are difficult to "hide" with a thin cover coat. The ground coat should not be fired down hard because of the likelihood of "shiner scale" which tends to "float up" through the thin single cover coat. It will be found preferable to underfire slightly rather than to overfire. Lumps, blisters, and other similar defects must be kept at a minimum.

(3) Cover-Coat Application Control

It is essential that close supervision be given the cover-coat spraying department as to weight of application, inasmuch as a variation of more than $\pm^1/_5$ ounce (about 5 grams) will result in color-matching difficulties in the assembly department. The tendency to tear will also increase with increase in thickness. Control is important from a materials cost viewpoint as every pound of enamel less on the ware actually represents about two pounds, when the losses through the exhaust and in the department are considered.

(4) Drying and Handling

Probably the most important step in connection with a one cover-coat finish is drying and handling the dry, unfired enamel. Drying must be thorough, particularly with difficult shapes, to avoid tearing. This applies to normal slip fineness as well as to the finer milling, although the tendency to tear is greater with the finer slips. Drying slip milled to 1% on a 325-mesh sieve requires a

[1] F. R. Porter and H. H. Holscher, "Use of Finely Milled Enamel Slips," *Jour. Amer. Ceram. Soc.*, **18** [2] 39–42 (1935).

much longer time than drying one of normal fineness, *i.e.*, 7% on a 200-mesh sieve.

The handling too must be more careful to avoid tearing, starring, etc. In general, the average enamel-shop personnel requires extra training before a one cover-coat finish is successfully obtained.

Pfeiffer and Cook[2] have given a good résumé of prerequisites for single cover-coat finishes. The experience of the writers has paralleled theirs as to the amount of care required in all stages of the work. Other shops have verbally corroborated these findings. The goal, however, is worth working for and is attainable with well-directed, patient effort.

[2] W. H. Pfeiffer and H. L. Cook, "Essential Factors for One-Coat Finishes," *Enamelist*, **11** [3] 19–20 (1933).

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MINIMUM RADIUS OF CURVATURE FOR ENAMELED PARTS*

By H. H. Holscher

Abstract

A comparison of the firing off and chipping of porcelain enamel over bent edges of various outside radii shows that $^9/_{64}$ inch is the minimum radius to which the iron should be bent.

I. Introduction

Enamel technicians frequently mention certain features of design which contribute to high enamel losses and usually confess that much can be accomplished by minor changes in design by one who is familiar with shop processing. With this idea in mind, extensive studies of certain design features from the enameling viewpoint have been made.

II. Definition of Problem

Perhaps the design feature most common to all products is that of the sharpness of bent edges which are to be enameled. A sharp edge can not be perfectly covered with porcelain enamel because this edge oxidizes during the firing period, thus producing more oxide than can be taken into solution by the ground coat. Various stages of oxidation may cause a ground coat to pass from a perfectly normal fired appearance to a completely fired-off condition; these stages are too common to merit further description.

This work was guided by the following general considerations: (1) A bent edge should be such that it can be sent through the enameling process without special precaution or without developing any difficulties in processing. Ground-coat reinforcement before (or reworking after) firing is highly undesirable. Reinforcing before firing may result in too heavy application at the bent edge and consequent possible underfiring while patching after firing is expensive. The ground coat should be satisfactory in its original firing as well as after two subsequent firings for the cover coats. Edge reinforcement during cover-coat application is undesirable.

When special precautions are necessary to give a perfect cover coat on a bent edge, exceptionally thick enamel is usually the result. A type of "spontaneous" chipping may then be noticed if the bend is too sharp.

(2) The attainment of coverage on a single bent edge of a part offers a simple problem compared with the cases where all of the edges of a 24- by 42-inch cooking top must be perfect. Proper draining as well as proper firing of four edges gives much more trouble than with a single edge.

III. Experimental Procedure

This work will define a radius limit which lies on the "ragged edge," but, wherever possible, more leniency should be given and a larger radius specified unless other more important factors govern.

To determine how sharp the bent edge could be without requiring special attention in processing,

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

four series of eleven panels each were made of 20-gage iron (0.037 inch thick) with two bent edges, having outside radii of bends as follows: $^1/_{16}$, $^5/_{64}$, $^7/_{64}$, and $^9/_{64}$ inch. These panels were carefully pickled and enameled in the laboratory.

In the major portion of the work, the entire panel was covered with one cover coat, one stainless cover coat, and a rework stainless cover coat. The condition of the enamel over the bent edges at various points in processing was noted by measuring accurately the percentage of the enamel which was unsatisfactory, of questionable use, or unusable. The radii of the bends over the cover coats were also measured.

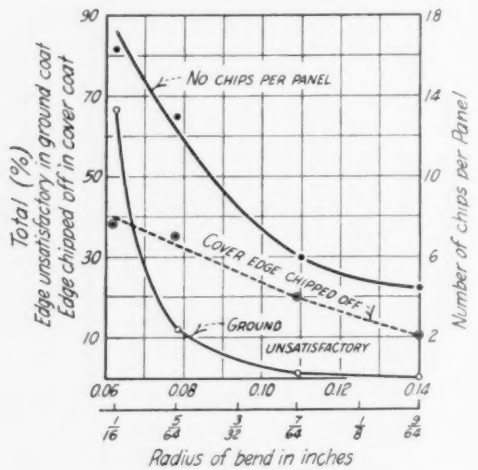

FIG. 1.—Firing off and chipping *vs.* radius of bends.

Further studies consisted in producing chipping on the bends by a thermal shock test. The panels were quenched ten times from an oven at 500°F into water at 50°F. This gave a high percentage of failure (shearing off of enamel over the bent edges) which was desired for comparative purposes. Necessarily, some fishscaling was produced with this extreme test.

Some of the panels were processed in cover coat with the bent edges brushed to expose the ground coat during subsequent firings, and the firing-off of the ground coat was noted. Reworking and patching of ground coat and their effects on defects in the cover coats received attention.

IV. Results

The results of these measurements are summarized in Table I, with the more pertinent data presented in Fig. 1.

V. Conclusions

(1) Where firing off of the ground coat on the bent edge is tolerated and when no cover enamel is applied over it, the radius may be as sharp as is possible to produce with the gage of metal used.

(2) If the bent edge must be perfectly covered either with ground coat (after two cover-coat firings) or with ground coat and cover coat, the radius of surface to be enameled should not be sharper than $^9/_{64}$ inch.

(3) Firing off of the ground coat over the bent edges becomes very serious where the radius becomes sharper than $^1/_8$ inch. In fact, it is only eliminated when a radius of $^9/_{64}$ inch or greater is used.

(4) A perfect cover coat may be secured only when the ground coat is perfect. Reworking of the ground coat gives better results than attempting to cover an imperfect ground coat and then having to rework in the cover coat.

(5) From the standpoint of appearance there is little if any advantage in using a radius sharper than $^9/_{64}$ inch. Piling-up of the cover-coat enamel over the bent edge tends to produce a larger radius, which gives the same appearance as a larger steel radius on which less piling-up occurs. Obviously, the resultant thicker enamel at the bent edge is undesirable.

(6) Tests on welded corners have shown that one of the greatest difficulties encountered is the

TABLE I

ENAMEL PROPERTIES *vs.* SHARPNESS OF RADII

	Group No.			
	1	2	3	4
Inside radii of bends	0	$^1/_{32}$	$^1/_{16}$	$^3/_{32}$
Outside " " "	$^1/_{16}$	$^5/_{64}$	$^7/_{64}$	$^9/_{64}$
Total edge in ground coat (%)				
Unsatisfactory 1st firing*	67	12	1.1	0.0
Fired off " "	43	2.5	0.9	0.0
O. K. " "	33	88	98.9	100
O. K. by reworking	45	92.5		
Total edge in two cover coats (%)				
O. K. over ground (not reworked)	17	80	100	100
O. K. over reworked ground coat	50	92.5		
Total edge in reworked cover coats (%)				
O.K. over ground (not reworked)	32	80	100	100
O. K. over eworked ground coat	60	95		
Outside radii over cover coats	$^7/_{64}$	$^7/_{64}$	$^8/_{64}$–$^9/_{64}$	$^{10}/_{64}$
Radii gain due to cover coats "piling-up"	$^3/_{64}$	$^2/_{64}$	$^1/_{64}$–$^2/_{64}$	$^1/_{64}$
Av. number chips of cover coat at bend per panel	16.4	13.0	6.0	4.5
Total cover coat edge chipped off (%)	38.5	35.1	20.3	10.5
First chipping occurred	Before quenching	At 1st quenching	At 3d quenching	At 4th quenching

* Includes that which is fired off as well as that which was very thin and somewhat glossy but still considered unsatisfactory.

coverage of short edges left too sharp during the grinding.

(7) Twice as much chipping occurs over a bent edge with an outside radius of $^{7}/_{64}$ inch as on one with a $^{9}/_{64}$-inch outside radius. A similar ratio exists with bends of $^{1}/_{16}$-inch outside radius and $^{7}/_{64}$-inch outside radius.

(8) On panels made with bent edges of $^{9}/_{64}$-inch radius, there was about the same tendency to fishscale on the center of the panel as there was to chip over the bent edge.

(9) Parts with greater radii did not chip until the third and fourth quenching while with the sharper radii chipping occurred at the first quenching. The $^{1}/_{16}$-inch group had two chips before quenching began.

EDISON GENERAL ELECTRIC APPLIANCE COMPANY
5600 WEST TAYLOR STREET
CHICAGO, ILLINOIS

A METHOD FOR TESTING THE ADHERENCE OF GROUND COATS TO METAL*

BY C. J. KINZIE AND J. B. MILLER

ABSTRACT

An apparatus for testing the adhesion between ground-coat enamels and the sheet-iron base is described in detail and results are discussed.

I. Description

The apparatus is essentially a No. 3 Arbor press equipped with the accessories necessary for this test. These consist of (1) one steel ball, $1^{3}/_{4}$ inches in diameter; (2) one cold rolled steel plunger, $2^{5}/_{8}$ inches long, $2^{1}/_{4}$ inches in diameter for one inch at the top and $1^{3}/_{4}$ inches in diameter for the remaining $1^{5}/_{8}$ inches at the bottom; the $^{1}/_{4}$-inch shoulder thus formed limits the downward movement of the steel ball to $^{5}/_{8}$ inch, which is the extreme length of travel; and (3) two cast-iron plates used for holding the specimen. The bottom plate is 12 inches square and one inch thick, with a 2-inch hole drilled in the center. The top edge of the hole is rounded off to a $^{3}/_{8}$-inch radius to prevent a break in the metal (see Fig. 1).

The top plate is 12 inches square and one inch thick with a boss in the center. This boss is $3^{1}/_{2}$ inches in diameter and $1^{3}/_{4}$ inches high, with a $1^{3}/_{4}$-inch hole drilled on the center line. The hole acts as a guide for the plunger and the $1^{3}/_{4}$-inch steel ball. At each corner the top plate is drilled and the bottom plate tapped for $^{1}/_{2}$-inch capscrews to hold the specimen in proper position and to align the center holes.

This apparatus is designed to test ground-coated panels 6 to 10 inches wide and at least 6 inches in length. The 10- by 15-inch panel was found to be a convenient size to use.

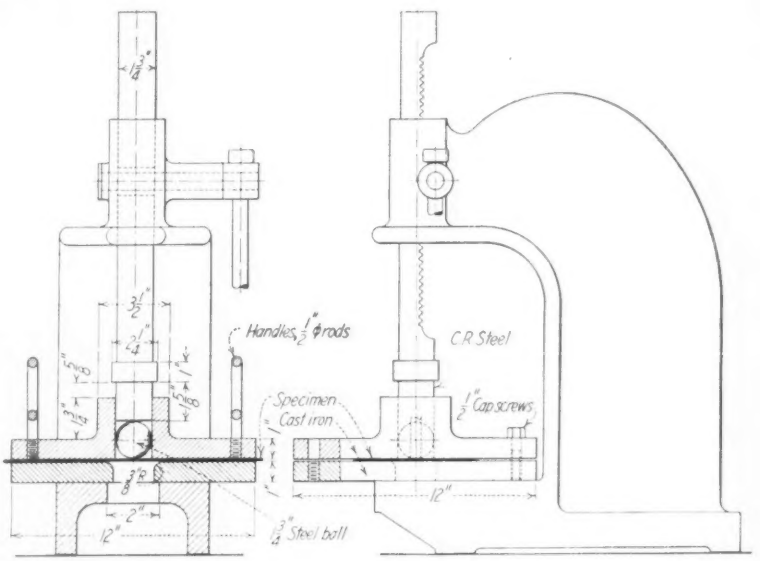

FIG. 1.—Adherence testing apparatus.

II. Test Procedure

The ground-coated panel was placed between the two cast-iron plates and the capscrews were tightened to hold it firmly in place. Pressure was applied slowly and as uniformly as possible by

*Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

the hand lever on the arbor press until the shoulder on the plunger met the boss on the top plate. The specimen was then removed from the apparatus for observation.

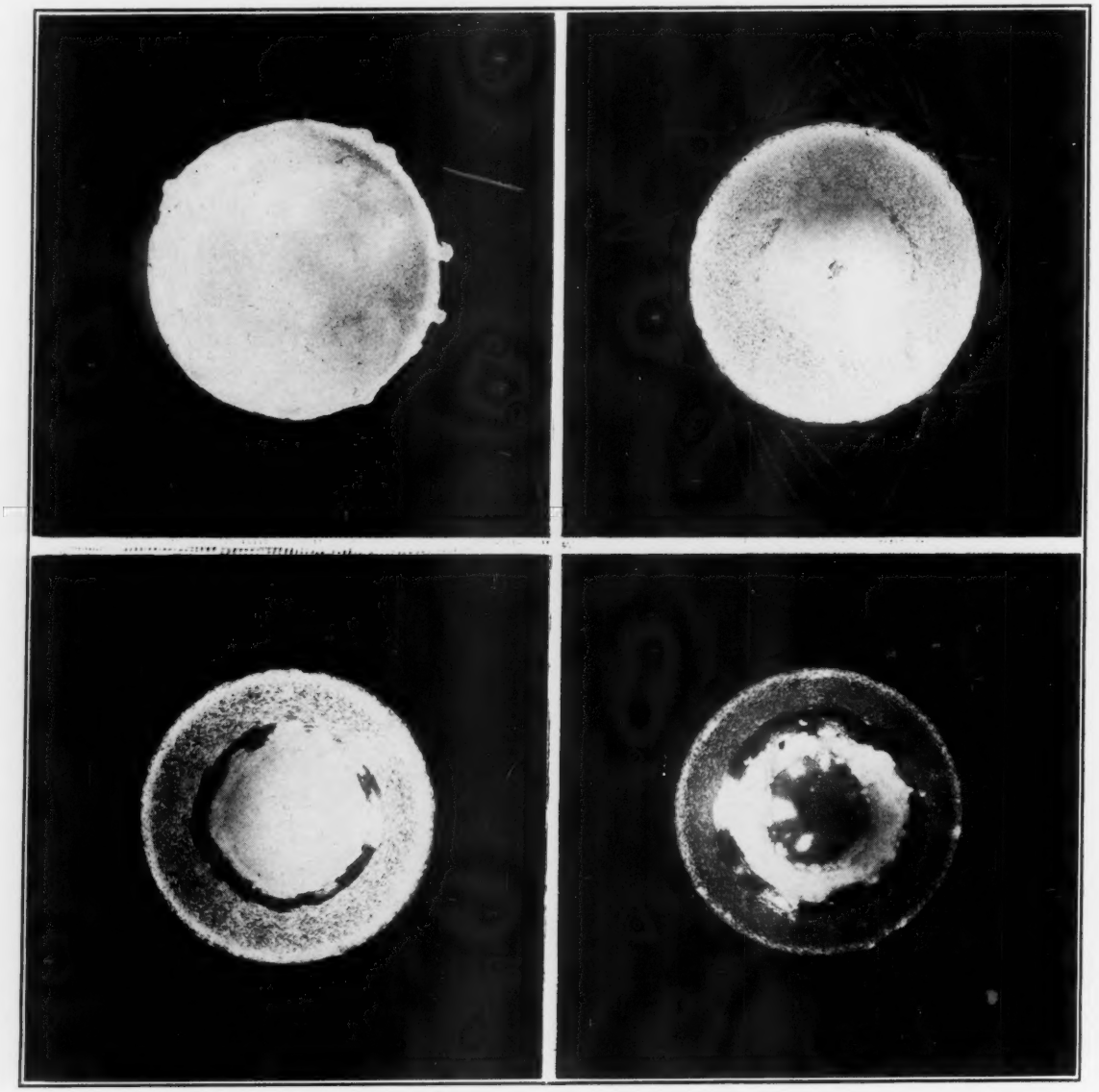

FIG. 2.—Upper left, enamel A; upper right, enamel B; lower left, enamel C; lower right, enamel D.

III. Discussion

Figures 2 to 4 are included to show the difference in adhesion of four enamels.

Enamel A

Figure 2 (upper left) shows very poor adherence. All of the enamel in the deformed area has flaked off leaving the metal bright with no adhering particles.

Enamel B

Figure 2 (upper right) also shows poor adherence, but it is somewhat better than enamel A as shown by small adhering particles of enamel and the etched surface of the metal in the deformed area. The failure of the enamel in the stressed area surrounding the deformed area also indicates poor adherence. This failure is shown in the photograph by the lines extending out and away from the deformed area.

Enamel C

Figure 2 (lower left) is an example of fair ad-

herence. In this case, much more enamel was left adhering to the metal in the deformed area than with enamels A and B.

Enamel D

In Fig. 2 (lower right), the enamel shows very good adherence. The very dark outer rim of the deformed area shows the excellent bond that has been developed between the metal and ground coat. The circular area of ground coat in the vortex of the deformed area is also a favorable indication of very good adherence.

IV. Conclusions

This apparatus has been a valuable aid in the development work done on ground coats in this laboratory and has also been helpful in determining (1) the effect of firing time and temperature on the adherence of a ground coat and (2) what can be expected from a ground coat when put into plant production.

This machine is a modification of the Erichsen ductility testing machine and Wm. V. Knowles is credited with the idea.

Research Laboratory
Titantium Alloy Manufacturing Company
Niagara Falls, New York

LABORATORY CONTROL IN DRY-PROCESS ENAMELING*

By R. D. Cooke

Abstract

A description is given of the methods used for controlling raw materials and mixing, melting, and applying dry-process enamels for cast-iron sanitary ware.

I. Introduction

The raw materials for dry-process enamels are substantially the same as for wet process, the difference in batch compositions arising from the fact that no mill additions are used and all of the opacifier is incorporated in the melt. The latter usually takes the form of antimony compounds, aided occasionally by tin oxide or zirconium compounds. In general, a high order of purity and freedom from contamination is required due to the fact that these enamels are responsive to sources of color such as manganese, copper, chromium, and some compounds that may result from the interaction of otherwise pure materials. Curiously enough, iron, as such, is not a troublesome source of color if it is in an oxidized state and finely divided enough to be dissolved in the melt. On the other hand, metallic iron can be very troublesome, not only in the raw materials but at later points in the process where such contamination is possible.

II. Importance of Chemical Analysis

Chemical analysis of raw materials for mere content of wanted ingredients is not enough. Batch compositions are always computed on the basis of such analyses, but when evaluating a material from a new source it is always necessary to rely on trial melts for the detection of color-producing impurities, which may escape detection in the ordinary analysis and which may even defy identification after their presence is known.

The basing of batch compositions on analyses of the materials is important and worth while in the compounding of any enamels, but especially so in dry process because of the greater thickness to which these enamels are applied. This demands a finer balance of coefficient of expansion to eliminate stresses in the finished enamel. A deliberate change of 1% in the calculated coefficient of expansion in either direction is sufficient to cause a distinct tendency for the enamel to craze when increased or chip when decreased. The final adjustment in this respect may be made with small variations in silica, boric oxide, or sodium oxide and is conveniently done by changing slightly the soda-ash content of the batch.

With reference to mixing, there is little that differs from other practice except that it must be thorough to insure rapid melting, since all of the opacifier is in the batch and prolonged melting would result in loss of opacity.

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

III. Quenching and Grinding

Melting requires no special comment since it follows conventional methods. From the point of quenching the frit to the finished product, however, every precaution is taken to avoid contamination by metals, especially iron. On account of the grinding being considerably coarser than with wet enamels, particles of dirt are more likely to be carried along and result in objectionable blemishes in the finished product. Quench tanks are lined with porcelain brick set up in a special cement free from dark-colored ingredients. Frit containers are lined with Monel metal or stainless steel, and the rotary drier is lined with porcelain brick.

IV. Frit Should Be Damp to Grind Well

Naturally the frit is ground dry, but it has been found that the presence of a very minute amount of water improves the rate of grinding and makes the powder seem drier. Much of the time the natural humidity of the air supplies enough moisture for this effect, but in cold or extremely dry weather it has been found advantageous to add one or two ounces of water to one thousand pounds of frit. When the frit and the air are perfectly dry there is a tendency for the powder to pack on the balls and on the sides of the mills, having the superficial appearance of being too wet. A possible explanation of this, for which there is really no experimental evidence, is that the powder, when dry, accumulates a static electrical charge and when the air is moist it is conducting and allows the charge to drain off or possibly causes a reversal of polarity.

V. Control of Fineness

Milling may be done either in batch or continuous mills. In the latter type, the fineness is controlled primarily by the rate of feed. Dry enamels work well at 30 to 40% on 200-mesh. The fineness is checked and controlled by frequent screen analyses. Colored enamels are ground somewhat finer, approximately 20% on 200-mesh. Colors are ground in batch mills, and each lot is submitted for a laboratory test before it is used. A sample plate is made and compared with standards under daylight and artificial light.

VI. Thickness of Enamel Coat

The enameling process control takes the form of specifying and checking the quantity of enamel applied to each kind of casting. A determination is first made of the weight of coating in grams per square foot which results in adequate covering or reflectance. It is necessary that this quantity be near the level part of the reflectance curve so that variations above or below do not cause objectionable contrasts. This can then be translated into thickness as measured by the micrometer and into any other units that may be convenient in practice.

The next step is to estimate the surface area of each class of castings by a process of dividing the surface into elements of which the areas can be measured and of adding all of these together. From these data a standard weight of enamel for each casting is computed.

Verifying the weights actually used may be done in a number of ways. For a day-to-day approximation of the enamel used by each operator, the net weight of powder he has used is divided by the number of pieces made. This is useful only when the enameler has made the same pieces throughout his shift. If a piece is scrapped for any reason, some of the enamel can be chipped off and measured with a micrometer. For precise checking, each casting is weighed before and after enameling.

Up to the present time it has not been found practicable to carry out this last practice on a large scale, but it may prove desirable to do so. The difficulty arises from the fact that many of the castings are large and heavy. With castings that take an hour or two to cool and two men to move, the difficulties multiply rapidly. The solution to the control problem at this point undoubtedly lies in adopting, as a routine part of production, the regular practice of weighing each casting before and after enameling.

No mention has been made of the items of laboratory control that relate to foundry and other operations. These are no less an integral part of the control problem, but they are of less immediate interest to enamelers and need not be included in this discussion.

Rundle Manufacturing Company
Milwaukee, Wisconsin

ACTIVITIES OF THE SOCIETY

EDITORIAL

INFLUENCE OF IMPROVED DESIGN ON MARKETING STRATEGY

Speaking in the symposium on "The Influence of Improved Design on Marketing Strategy," at the Thirteenth Annual Conference of the National Industrial Advertisers Assn., held in Pittsburgh, Pa., September 18 to 20, 1935, Ely Jacques Kahn, New York architect, made comments demanding the attention and thought of ceramic engineers and technologists. The following is a report of Mr. Kahn's remarks[1]:

In his prophecy of the architecture of 1936 and its relation to the development and marketing of products for the building industry, Mr. Kahn contended that wet work will not continue in our construction. By wet work, he included concrete, brick masonry, and plaster, and paint applied coat by coat. He declared these a survival of the mud age. That we are transcending it is indicated by the increasing use of light steel joists, steel frame work, and roof construction in which precast slabs of concrete or other materials will be fitted into the vertical and horizontal frame. The frame and slabs will have provision for necessary pipes and conduits, radiators will be replaced by heating elements in the floors and walls, the building will be fireproof, verminproof, and foolproof. Partition panels of a great variety of materials will be available so that a change of room arrangement may be a simple operation compared to the usual dirt, dust, and annoyance necessary with plaster.

Mr. Kahn sees far more construction in glass, following further development of its application and more extensive educational work among both architects and public for better acceptance. As to metals for exterior and ornamental use, in general, those which have seen greater use in the last five years have been disappointing from the standpoint of permanency of finish and the problem of maintenance.

There is a very definite place for the prefabricated house, Mr. Kahn believes, but he sees the sloping roof as a natural development for protection against rain, snow, heat, and cold. In the study of these houses, the interesting thing to him is the great strides made in the mechanical equipment for them. Kitchens will have built-in compartments of steel; lighting will likewise be built in, eliminating customary fixtures; plumbing fixtures will be standardized to be assembled into a unit where individual taste can still be exercised in the choice of colors and accessories.

In conclusion, Mr. Kahn emphasized the fact that he has had occasion, time and again, to have materials, models, details of every nature submitted to him, and, unfortunately, often in that period the submissions were so bad, from his point of view at least, that he was faced with the problem of rejecting them, redesigning them, or making compromises which were distasteful. European imports, as in the case of hardware, lighting fixtures, lamps, furniture, etc., were considered merely because American manufacturers were stubborn about their standard or would not consider new models. What many people in our industries do not suspect is that of all of the designers, the architect, by training and experience, is most likely to be qualified to assist in this problem to an unusual degree by reason of his sense of mechanics and construction as well as design. Time and again new materials appear that are certain to stumble until by happy accident they reach a level of serious use. To be specific in this possibility of using architects' services in industrial design, the breadth of experience alone is an important asset.

Professional diffidence keeps architects from approaching the market and the thought may persist that the architects do not want such work. If the industries realized what had already been done satisfactorily, there would be prompt efforts to bring more architects into the industrial field, quite possibly to prepare for the architecture of 1936 as something more efficient, better looking, and acceptable in the final analysis to those who build.

[1] From *Ind. Marketing*, **20** [5] 14 (October, 1935).

INTERNATIONAL CONGRESS ON GLASS TECHNOLOGY PLANNED FOR 1936

Glass Division of the American Ceramic Society Plans to Participate in Meeting in England

U. E. Bowes, Chairman of the Glass Division of the American Ceramic Society, has announced the formation of a committee to collaborate with J. C. Hostetter on the character and extent of the participation of the Glass Division in the International Congress on Glass Technology to be held in England in 1936.

Dr. Hostetter, who represented the American Ceramic Society at the First International Congress on Glass and Ceramics, held at Milan, Italy, in September, 1933, also represented this Society and the United States of America at Venice when the International Commission for Glass Technology was formed (see *The Bulletin*, pp. 205–206 (August, 1934) for details).

Represented on this commission are The American Ceramic Society, the Deutsche Glastechnische Gesellschaft, and the Society of Glass Technology. The repre-

sentatives of these three societies on the International Commission comprise the Executive Committee.

The personnel of the committee appointed by Mr. Bowes is as follows: J. C. Hostetter, Corning Glass Works, Corning, N. Y., *Chairman;* J. S. Gregorius, Pittsburgh Plate Glass Co., Creighton, Pa.; S. R. Scholes, New York State College of Ceramics, Alfred, N. Y.; Francis C. Flint, Hazel-Atlas Glass Co., Zanesville, Ohio; H. H. Blau, Macbeth-Evans Glass Co., Charleroi, Pa.; F. W. Preston, Butler, Pa.; A. N. Finn, National Bureau of Standards, Washington, D. C.; and Alexander Silverman, University of Pittsburgh, Pittsburgh, Pa.

NEW MEMBERS

Corporation

SWINDELL BROTHERS, Bayard and Russell Sts., Baltimore, Md.

Personal

BEEMAN, A. H., 633 Buhl Bldg., Detroit, Mich.; refractories sales engineer.

BOYD, WALTER B., Box 171, Norris, Tenn.; T. V. A. Ceramics Research Laboratory.

KREIDL, WERNER, Vereinigten Chemischen Fabriken, Kreidl, Heller & Co., Vienna, Austria.

LOWE, JOHN L., Box 4, Muskegon Hts., Mich.; Campbell, Wyant & Cannon Foundry Co.

SPENCER, ERNEST H., W. I. Tycer Pottery Co., Roseville, Ohio; ceramic engineer.

WIGLEY, JOHN T., 207 Maplehurst Ave., Syracuse, N. Y.; supervisor, decorating dept., Onondaga Pottery Co.

Student

GASKINS, WARDEN W., North Carolina State College, Raleigh, N. C.

HAVELL, RICHARD F., University of Illinois, Urbana, Ill.

ROSENBLOOM, JERRY A., Missouri School of Mines, Rolla, Mo.

MEMBERSHIP STATUS

	September 30, 1935	October 25, 1935
Paid in full		
Personal	1199	1209
Corporation	186	186
Honorary, Life, and Complimentary	26	26
Deferred personal	34	33
Part-payment personal	53	51
Subscribers	441	442
Advertisers	35	35
Current Sales	225	225
	2199	2207

MEMBERSHIP WORKERS' RECORD

Corporation		Student	
L. C Roche	1	C. M. Dodd	1
		A. F. Greaves-Walker	1
Personal		C. L. Thompson	1
A. I. Andrews	1	GRAND TOTAL	10
C. E. Bales	2		
Donald Hagar	1		
C. W. Parmelee	1		
Office	1		

ROSTER CHANGES DURING OCTOBER*

Personal

BOWES, URBAN E., 3744 Brookside Rd., Toledo, Ohio. (Alton, Ill.)

CARTER, WILLARD K., Box 154, Columbus, Ohio. (1650 Wyandotte Rd.)

CAYFORD, JAMES M., Apt. 333, 420 Memorial Drive, Cambridge, Mass. (Columbus, Ohio)

CHRISTENSEN, JOHN B., JR., P. O. Box 314, Chula Vista, Calif. (Los Angeles, Calif.)

CIBELLA, ROSS C., 12112 Union Ave., Cleveland, Ohio. (3365 East 135th St.)

CLEVERLEY, ALBERT M., "Brooklands," Arthurs Lane, Greenfield, Nr. Oldham, Lancs., England. (Keighley, England)

CORSON, KENNETH P., c/o H. R. Corson, Issaquah, Wash. (Taylor, Wash.)

COUCH, ALBERT H., Libbey-Owens-Ford Glass Co., Rossford, Ohio. (Toledo, Ohio)

COUCH, E. G., JR., Corhart Refractories Co., Louisville, Ky. (Alton, Ill.)

CRISFIELD, A. P., United Clay Mines Corp., Trenton, N. J. (Savannah, Ga.)

DEBENHAM, WILLIAM S., 1420 Franklin, Danville, Ill. (1024 Logan Ave.)

DRAKE, ARTHUR D., New Castle Hot Top Co., New Galilee, Pa. (Metuchen, N. J.)

FAILMEZGER, HOWARD, 1243 Cameron Ave., Plainfield, N. J. (138 E. 7th St.)

FAIRCHILD, T. M., 505 Park Ave., Johnstown, Pa. (737 Franklin St.)

HALLSWORTH, STANLEY, 56 Coleshill Rd., Ward End, Birmingham 8, England. (1 Douglas Ave.)

HARDER, CHARLES M., Hull House, 800 S. Halsted, Chicago, Ill. (N. Y. State College of Ceramics, Alfred, N. Y.)

HUTT, GLENN A., Tenysle Court, Collins St., Melbourne, Victoria, Australia. (Cleveland, Ohio)

KOENIG, CHARLES J., Box 102, Minocqua, Wis. (Columbus, Ohio)

KRANER, HOBART M., Research Dept., Bethlehem Steel Co., Bethlehem, Pa. (Louisville, Ky.)

LONG, R. N., 109 Fairfield Ave., Newark, Ohio. (Houston, Pa.)

LUMLEY, JOHN H., 211 E. Chestnut St., Fort Dearborn Sta., Chicago, Ill. (5728 Kenmore Ave.)

LYON, KENNETH C., 1880 Colonnade Rd., Cleveland, Ohio. (Urbana, Ill.)

MCNAMARA, EDWARD P., Ceramic Dept., Mineral Industries Bldg., State College, Pa. (Alfred, N. Y.)

MADDEN, ROBERT C., 126 Erie St., Johnstown, Pa. (Gardner, Mass.)

MALINOSKY, A., JR., 5926 Rita St., Huntington Park, Calif. (Southgate, Calif.)

MARLEY, HENRY E., Ceramic Dept., University of Cincinnati, Cincinnati, Ohio. (Hornell, N. Y.)

MERWIN, BYRON W., 243 Campus Ave., Ames, Iowa. (Benton, Ark.)

MILLER, CHARLES T., 128 E. Grand Ave., Springfield, Ohio. (2535 E. Main St.)

* Address in parentheses is old address.

MOSS, JOSEPH W., Indiana State Highway Dept., Greenfield, Ind. (Spencer, Ind.)
PALMER, LAWRENCE A., U. S. Bureau of Public Roads, Washington, D. C. (National Lime Association.)
RIEDE, Mrs. FRED, Depue, Ill. (May C. Bowen, Canon City, Colo.)
SCHURECHT, H. G., 209 Jaques Ave., Rahway, N. J. (Long Island City, N. Y.)
SPENCE, C. FRANKLIN, 559 Columbian Ave., Columbus, Ohio. (598 Wiltshire Rd.)
TRUMAN, GAIL R., Hanley Company, Summerville, Pa. (Brazil, Ind.)
WILLS, GEORGE A., Washington Missionary College, Takoma Park, Washington, D. C. (Raleigh, N. C.)
WURTSBAUGH, CLARENCE G., 6801 Stafford Ave., Huntington Park, Calif. (Southgate, Calif.)

Complimentary Member

NEDERLANDSCHE VEREENIGING VAN AARDEWERKFABRIKANTEN, W. P. M. van der Loo, Secretary, Parkstraat 37a, The Hague, Holland. (Dr. Mulderije, Amsterdam, former secretary.)

LITTLEFIELD, BAGGS, HARDER, AND BOGATAY WIN CASH AWARDS AT ROBINEAU MEMORIAL CERAMIC EXHIBITION

The American Ceramic Society official exhibition of craft ceramics, the Fourth Annual Robineau Memorial Ceramic Exhibition, opened October 15, at the Syracuse Museum of Fine Arts, Syracuse, N. Y.

Edgar Littlefield, Instructor in Ceramic Art, Ohio State University, Columbus, Ohio, Arthur E. Baggs, Head of the Ceramic Art Division, Department of Fine Arts, Ohio State University, and Charles M. Harder, Instructor in Ceramics, New York State College of Ceramics, Alfred, N. Y., are members of the American Ceramic Society who were awarded cash prizes at the Exhibition. Paul Bogatay, associated with Mr. Baggs at Ohio State University, won the other cash award.

Mr. Littlefield won first prize of $50 in the art pottery group for a large white-glazed plate and a brilliant blue-glazed vase. This prize was donated by the Onondaga Pottery Co. Mr. Baggs entered a group of five copper-blue vases with semimat glaze. These won second prize of $25.

A turquoise blue plate, entered by Mr. Harder, was awarded third prize of $10. This prize was given by the United Clay Mines Corp., Trenton, N. J. Donors of first and third prizes are Corporation Members of the American Ceramic Society.

This group of five vases made by Arthur E. Baggs, Professor of Ceramic Art, Ohio State University, won second prize of $25 in the pottery classification. This prize was awarded by the Onondaga Hotel, Syracuse, N. Y., at which the meetings of the Art Division of the American Ceramic Society were held October 25 and 26.

Charles Harder, Instructor in the New York State College of Ceramics, Alfred, N. Y., was awarded third prize for the pottery shown in this illustration.

Glenn Lukens, University of Southern California, Los Angeles, won honorable mention for pottery.

First prize of $50 for ceramic sculpture, given by the trustees of the Syracuse Museum of Fine Arts, was awarded Paul Bogatay, Assistant in Design, Ohio State University.

His winning piece was a standing figure of a native woman, described by one of the judges as being an "honest interpretation, with nothing stunty or artificial about it; its simple sincerity earned first place for the entry."

Waylande Gregory and Sorcha Boru won honorable mention for sculpture.

In a statement issued after the jury had selected the winners, Richard F. Bach, Director of Industrial Relations, Metropolitan Museum of Art, Chairman of the Jury, declared, "As Chairman of the Jury may I recommend that my fellow members, Carl Walters and R. Guy Cowan, be granted special commendation for their entries in the

Fourth Annual Robineau Memorial Ceramic Exhibition.

As jurymen they are not eligible for award or even honorable mention, but I feel that the quality of their work merits special notice and suggest that such recognition be granted these artist-designers at the opening of the exhibition."

"Native Woman," a figure by Paul Bogatay, Columbus, Ohio, was awarded first prize of $50 for ceramic sculpture in the Fourth Annual Robineau Memorial Ceramic Exhibition. This prize was given by the trustees of the Syracuse Museum of Fine Arts.

The three jurors for the Fourth Annual Robineau Memorial Ceramic Exhibition are shown here. From left to right they are Carl Walters, ceramist, Woodstock, N. Y., Richard F. Bach, Director of Industrial Relations, Metropolitan Museum of Art, and R. Guy Cowan, Art Director, Onondaga Pottery Co., Syracuse, N. Y.

LOCAL SECTION NEWS

CALIFORNIA HONORS GENERAL SECRETARY

An enthusiastic crowd of more than seventy members of the California Section of the American Ceramic Society gathered on September 30 in honor of General Secretary Ross C. Purdy, who visited the Pacific Coast for the first time in ten years.

The General Secretary was introduced by Robert Linton who paid a well-deserved tribute to the unselfish effort put forth by Mr. Purdy for the betterment of the ceramic industry and for the recognition of the ceramic technologist in the field of industry.

Mr. Purdy responded with an address that absorbed the attention of his listeners and that created in the minds of the California members a new impression of the problems of the ceramic industry at large.

Mr. Purdy's reception by the California Section was in the nature of an ovation and his visit has left a lasting impression.—THOMAS S. CURTIS, *Secretary*

HENDRYX SPEAKS AT PITTSBURGH MEETING

One of the largest attendances ever recorded at a meeting of the Pittsburgh Section heard Dwight B. Hendryx, October 8, 1935, at Mellon Institute.

Mr. Hendryx, Chief Engineer, Harbison-Walker Refractories Co., led a discussion on "Tunnel Kiln Operating Problems."

A unique method of clearing up wrecks in tunnel kilns was mentioned by one of the members during the discussion.—EARL C. PETRIE, *Secretary*.

CENTRAL OHIO SECTION HEARS TALK ON ABRASIVES

Meeting at Battelle Memorial Institute, Columbus, Ohio, October 22, 1935, the Central Ohio Section of the American Ceramic Society heard a talk on "Some Phases of Grinding-Wheel Manufacture."

The speaker, Ross C. Purdy, General Secretary of the American Ceramic Society, traced the development of artificial abrasive products and the improvements in grinding-wheel manufacturing processes during the last four decades.

An informal discussion lasting over an hour closed the meeting.—C. R. A

NEW YORK STATE COLLEGE OF CERAMICS STUDENT BRANCH MEETINGS

Two meetings of this group of ceramic students were held early in November. On November 5, Ross C. Purdy, General Secretary of the American Ceramic Society, gave an address on "Technical Advances in the Abrasive Product Production."

Alexander Silverman, Head of the Chemistry Department, University of Pittsburgh, on November 12 addressed the Student Branch on "A Survey of the Glass Industry."

Representatives of ceramic industries in western New York State also attended these meetings.

FLOWERS FOR A LIVE ONE

L. E. Barringer, Chairman of the Art Division, and one of the major forces behind the various activities of this Division, has been responsible for much of the renewed interest in coöperation among the ceramic artists of America.

Giving whole-hearted support to the Society-initiated ceramic exhibitions, such as are now being held annually at the Syracuse Museum of Fine Arts, and meeting in informal groups during two days of the Fourth Annual Robineau Memorial Ceramic Exhibition to compare ideas on the topics chosen for discussion, members of the Art Division have participated in many nationally noteworthy ceramic activities during 1935.

Under the direction of Chairman Barringer, the set-up of this Division was reorganized as shown in *The Bulletin*, p. 242 (July, 1935).

The success of the meeting at Syracuse, the First Fall Meeting of the Art Division in the history of the American Ceramic Society, is the result of much effort on the part of Mr. Barringer, R. Guy Cowan, who represented the American Ceramic Society on the jury of the Robineau Exhibition, and C. C. Engle, Chairman of the Membership Committee of the Art Division.

Over a thousand invitations to interested artists and ceramists were sent out before this meeting, and notices of the meeting dates and the discussion topics were carried in many ceramic and art journals.

With continued strong leadership, the Art Division may well assume its position of leadership in creative ceramic activity in America, in both the industrial design and decoration and nonindustrial art and education phases of this activity.

Lawrence E. Barringer, General Electric Company, Schenectady, N. Y., Chairman of the Art Division of the American Ceramic Society.

Biographical Sketch

Lawrence Eugene Barringer was born in Washington, D. C., in 1876. He was graduated from high school there eighteen years later. During 1895 and 1896, he was employed by E. M. Freese & Co., Galion, Ohio, manufacturers of brick machinery. Two years later he was a shop student, American Terra Cotta Co., Crystal Lake, Ill. In 1900 to 1901 he was employed as chemist by the Columbus Brick and Terra Cotta Co., Union Furnace, Ohio.

In 1902, he received his degree, E. M. in Ceramics, at Ohio State University. He was employed by the General Electric Co. as a ceramic specialist and in 1909 he became Engineer of Insulations for this Company. He still holds this position.

Mr. Barringer joined the American Ceramic Society in 1905 and beginning with his election to the presidency of this Society in 1916, he has held many positions of responsibility.

Between 1918 and 1920, he was Chairman of the Committee on Publications, starting *The Journal of the American Ceramic Society*. This publication succeeded the *Transactions of the American Ceramic Society*, an annual publication then in its nineteenth volume.

Since 1924, Mr. Barringer has been Chairman of the Committee on Rules for this Society; in 1933 he was Dean of the Fellows.

Being appointed Chairman of the Art Division in 1933, Mr. Barringer has since held this post and was largely responsible for the widely appreciated Art Division number of *The Bulletin* issued in November, 1934.

Mr. Barringer is a member of Phi Delta Theta (1898) and of Tau Beta Pi fraternities. He was elected to this last society in 1931. He is also a director of Locke Insulator Corporation and Monowatt Electric Corporation.

His publications have appeared in several journals, some of them are listed below:

Transactions of the American Ceramic Society

"The Relation between the Constitution of a Clay, and Its Ability to Take a Good Salt Glaze," **4,** 211 (1902).
"Note on Vapor Glazing," **5,** 105 (1903).
"A Method for Making Enameled Brick," **5,** 256 (1903).
"Influence of Magnesia on Clay," **6,** 86 (1904).
"Note on a Black Speckle for Use on a Red Face Brick," **6,** 198 (1904).
"The Construction of a White Ware Pottery," **6,** 203 (1904).
"Strength of Sagger Bodies," **7** [Part II], 201 (1905).
"Measurement of Settle in Brick Kilns," **7** [Part III], 409 (1905).
"Hydrous Silicates Formed under Steam Pressure," **15,** 125 (1913).
"A Continuously Operated Tunnel Kiln for High-Grade Clay Ware," **18,** 106 (1916).
"Presidential Address," **19,** 69 (1917).

Journal of The American Ceramic Society

"The Comparative Value of Kneading and Pugging in the Preparation of Porcelain Bodies," (in coöperation with Chester Treischel), **2,** 306 (1919).
"Application of Electric Heat to Vitreous Enameling," **4,** 461 (1921).

General Electric Review (Schenectady, N. Y.)

"Porcelain for Electrical Purposes," **10** [4], 160 (March, 1908).
"The Importance of Standards in the Evaluation of Insulating Materials," **27** [11], 736 (1924).
"A Revolutionary Development in Mica Insulation," **29** [11], 757 (1926).
"Molded Insulation," **30** [8], 387 (1927).
"Glyptal Mica Moves Ahead—Now the Flexible Form," **32** [10], 530 (1929).
"Glyptal Lacquers," **32** [12], 660 (1929).
"Mycalex—A Molding Material with Unique Properties," **34** [7], 406 (1931).
"Glyptal in the Foundry," **34** [12], 736 (1931).
"Far-Flung Foes of Insulation," **37** [11], 498–503 (1934).
"Porcelain and Porosity," **38** [7], 308–11 (1935).

Wisconsin Engineer (published by University of Wisconsin, Madison, Wis.)

"Importance of Insulation in Electrical Engineering," **29** [7], 130 (April, 1925).

NECROLOGY

Benjamin Frosterus

Benjamin Frosterus, Helsingfors, Finland, died early this year according to word received recently from Helsingfors.

Professor Frosterus was Director of the Soil Institution of Finland and since 1926 had been a member of the American Ceramic Society.

NOTES AND NEWS FOR CERAMISTS

Weidlein Awarded Chemical Industry Medal

Edward R. Weidlein, head of the Mellon Institute of Industrial Research, Pittsburgh, Pa., has been awarded the Chemical Industry Medal of the Society of Chemical Industry.

In recognition of the valuable applications of chemical research to industry that have been carried out under Dr. Weidlein's direction, the award was made at a meeting held jointly with the American Chemical Society, November 8, 1935.

Dr. Weidlein presented a paper entitled "Various Results of Being Researchful." L. V. Redman spoke on the subject of the medalist, and D. D. Jackson, Columbia University, presented the medal.

A G. Johnson Advanced at Western Electric

A. G. Johnson, who was graduated from the Department of Ceramic Engineering, Iowa State College, Ames, Iowa, in 1924, and has since that time been employed with Western Electric Company as an engineer, mainly on ceramic development work, was advanced on October 1 to Chief of the Department on Raw Material Development.

Mr. Johnson will have charge of a group of men concerned with specification requirements and other development work on a majority of the raw materials used by the Company.—L. I. SHAW.

Budnikoff Appointed Dean of Faculty at Charkoff

Peter P. Budnikoff, Professor of the Charkoff (U. S. S. R.) Institute of Chemical Technology, where he fills the Chair of Technology of Silicates, has recently been appointed Dean of the Faculty of the Technology of Inorganic Matter. In 1934 he was awarded the degree of Doctor of Technical Science. November, 1935, will be the twenty-fifth anniversary of the beginning of his scien-

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tific and pedagogical activities. During this quarter of a century he has published in scientific magazines in several countries more than 300 papers and has obtained about twenty patents for inventions.

Professor Budnikoff is Chairman of the Ukrainian Scientific Technical Society of the Cement and Ceramic Industry and member of the editorial committees of several scientific journals in the Soviet Union.

—E. E. STEFANOWSKY

Tone Awarded Edward Goodrich Acheson Medal

Frank J. Tone was formally presented with the Edward Goodrich Acheson Medal, October 8, 1935, at Washington, D. C. See also *The Bulletin*, p. 187 (May, 1935).

COMMUNICATIONS—CERAMIC HISTORY

TILE VERSUS TERRA COTTA*

Tile, in preference to terra cotta, is recommended for swimming pool installations by the writer who cites the findings of his research laboratory to prove his points: (1) tile may be glazed or unglazed; terra cotta is only suitable when glazed; (2) tile have highly refined bodies; terra cotta body is crude; (3) glazed tile, suitable for pools resist crazing more than glazed terra cotta; (4) tile must be set by careful workmen; machine-made terra cotta may be set by a bricklayer; and (5) Roosevelt's pool in Washington is of terra cotta, but this was a special job, only perfect and true pieces being used.

* Abstract of an unsigned article appearing in *Keram. Tile Jour.*, **7** [6] 14–15 (1935).

TERRA COTTA DEFENDED†

BY ECKARDT V. ESKESEN

The writer of the article "Tile *vs.* Terra Cotta" does not know this subject. He has evidently seen some jobs made of materials other than terra cotta and from them has formed his judgment as to the terra cotta block. It would have been easy for him to have investigated the matter thoroughly before writing so self-confidently about this matter.

Terra Cotta Quality

The Federal Seaboard Terra Cotta Corporation is supplying 8- by 16-inch terra cotta block for hundreds of jobs all over the country. Of course I can talk only about the product which is manufactured by my Company, but I do not know where the writer of the above-mentioned paper gets the idea that the 8- by 16-inch terra cotta block as manufactured by this Company are "crazing, contain pinholes, stickers, and spots," "that the terra cotta material used for the body and the method of manufacture is crude, and that it is not really straight and true and gives an unsightly surface," etc.

Neutral Standpoint

Considering that the writer is in both the terra cotta and tile business, I can perhaps take a neutral standpoint and judge the issue more clearly.

A great deal has been done by the Federal Seaboard Terra Cotta Corporation and also by other terra cotta manufacturers in promoting terra cotta, including the terra cotta wall ashlar block, but I know of only one or two cases where there has been direct competition with wall tile. In many cases, jobs have been promoted at the same time by both terra cotta and tile people. The tile manufacturers do not need to talk down terra cotta or other ceramic materials in order to create work; there are plenty of jobs waiting to be developed in tile, but in which other substitutes are being used. There are hundreds of swimming pools being built of concrete, bathrooms being furnished with imitation material, etc. This Company, in looking around, has found new fields never dreamed of before that could be developed in terra cotta. We are now supplying this block and terra cotta for incinerators, sewage disposal plants, steamship piers, gasoline stations, cafeterias along the highways, and similar jobs.

Terra Cotta for Pools

Terra cotta has been used for swimming pools for many years in the United States. The Northwestern Terra Cotta Company made scum gutters, ceramic steps, and cove base for swimming pools furnished by the American Enameled Brick Company under the Boerum patent.

Our Company has supplied terra cotta for several exterior and interior pools and does not as yet know of any failures or crazing of the material either on the surface or under water. The surface of our 8- by 16-inch terra cotta block is straight and true and ground absolutely to size, so that if necessary it can be set to $^1/_{32}$-inch joint. This is true in all instances, whether in swimming pools or other work (the President's swimming pool included). It can be made in any color desired. There is no limit to the application of colors any more than there is concerning wall tile or any other ceramic material.

We are also producing a much larger unit than could be made in tile. Our materials, in many instances, are made part of the structural wall and in some cases used as a wall-bearing unit. Tile can not be used for this purpose.

Amount of Absorption

Terra cotta does have a higher absorption than tile, but it has not yet been finally decided by the experts what amount of absorption is the proper one. It has been proved, however, that bodies with a minimum absorption

† Reply to "Tile *versus* Terra Cotta."

will not, in setting, absorb enough mortar to be securely bonded to the wall.

It has also been found that bodies with the minimum absorption will not be able to absorb any moisture or salt which may evaporate from the wall but is liable to be pushed off.

Coöperation of Tile and Terra Cotta Makers

After all, terra cotta and tile are not in competition with each other or with other ceramic materials. Both industries are in hard competition with substitute materials and they should join hands to fight off these competitors successfully.

MODERN CERAMICS AND THE MUSEUM*

By William M. Milliken

Ceramics in the past have revealed much of the history of many peoples, but if a great catastrophe wiped out our nation what part would fragments of present-day ceramics play in revealing the quality of our civilization?

Are these objects, other than the products of mass production, close to life or are they only casual pieces so specialized that they have very little common appeal or usefulness? Of course the standards of mass production should not be used to judge these works, but the useful object can be individual and still come close to life. The individual and expressive part of present-day production has been to a great extent crushed by production needs and costs.

Quality Object *versus* Machine Product

Technically, our age may have progressed far, but our technical equipment may have contributed largely to our enslavement to the machine. The technical resources should certainly be put to the service of the machine, so that what it makes becomes better, but the way should also be left open for the handmade and individual product.

The only hope in this industrial age is to assure craftsmen that there is a place for the useful object of quality as well as for the machine product.

This emphasis on the *purposeful* should be noted. There is a limit to the vases one can use, but there are many things which are commonly needed which have been ignored because the so-called art ceramic worker has often scorned usefulness and has created, in an impractical void, a thing which has a relation to him but none to life.

It may, perhaps, even then have had its place and its beauty, but the ultimate possessor has been supposed to come all the way to the potter instead of the potter, without giving up one jot of his deepest beliefs, meeting the purchaser on common ground.

The greatest things in the past have usually been objects created for a purpose and a use, religious or otherwise, and the very discipline of having to create for that purpose and use has brought out the conflict between mind and matter which developed the creative idea. Experimentation has a definite and necessary place in such a scheme of things.

Museum and the Art Object

The relation of this paper to the subject given may be more apparent when the museum is considered from the writer's viewpoint. To the writer, the museum is a repository of the living art of the ages, those objects, irrespective of the technique or material involved or the idiom in which it is expressed, by which the genius of man speaks. The art object worthy of preservation is always representative of life and, therefore, inevitably relates itself to the social and historical picture of its time.

In the light of these beliefs, it is natural that The Cleveland Museum of Art has acquired objects created by its citizens. Further, because Cleveland ceramics have reached a high development, a certain number of characteristic pieces are included in its collections. Fifteen years past the Museum realized that there was a nascent interest in ceramics as such, apart from the purely commercial production. All of the prestige of the Museum was thrown behind the ceramic artists to encourage the artist. Further than that all of the prestige of the Museum was pressed into service to encourage the patron. One without the other is impossible, and a good start has been made in developing this mutual relationship.

Relation of Purchaser and Craftsman

Under the general term, the Machine Age, by which present-day civilization is labelled, there is a greater variety and desire for individualism than appears on the surface. That desire of the artist and public must be met and capitalized.

There are always a few public-spirited citizens who may buy a few pieces to help a cause. At best that is artificial. If beautiful objects of definite usefulness, objects related to our lives, are created, purchase of these products will come from basic economic reasons, and the whole structure is built on a far sounder foundation.

Somehow, efforts must be made everywhere to draw patron and artist together in some such way as The Cleveland Museum of Art has endeavored to do. If this vital emphasis of purchaser and craftsman were more widespread, perhaps the perils of standardization, against which the world is accustomed to rail without doing anything, might be confronted with greater success, and creative handicrafts might come back to a sounder and, as it will be then, a closer and less artificial relation to life.

Cleveland Museum of Art
Cleveland, Ohio

* From a paper presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Art Division).

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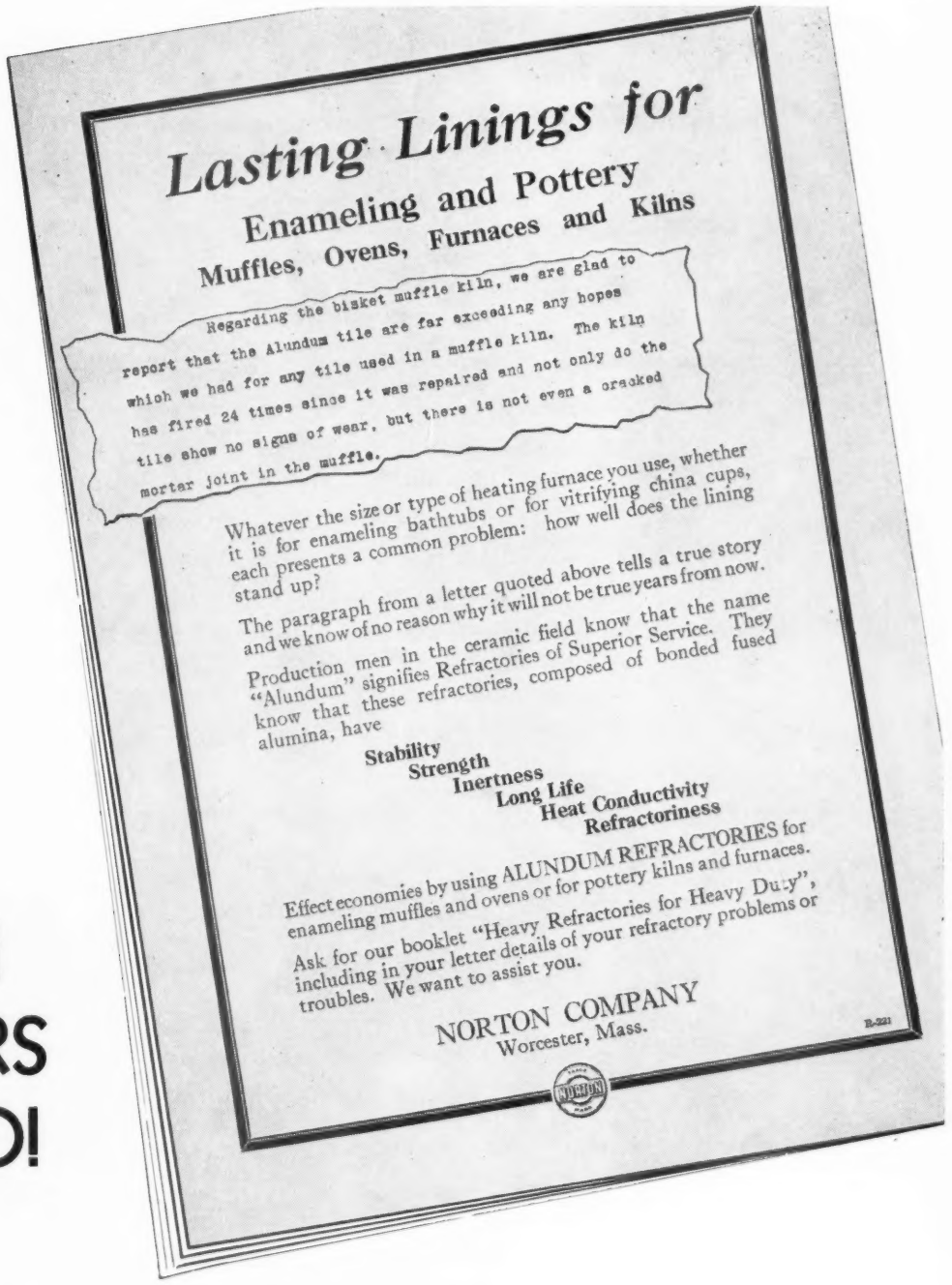
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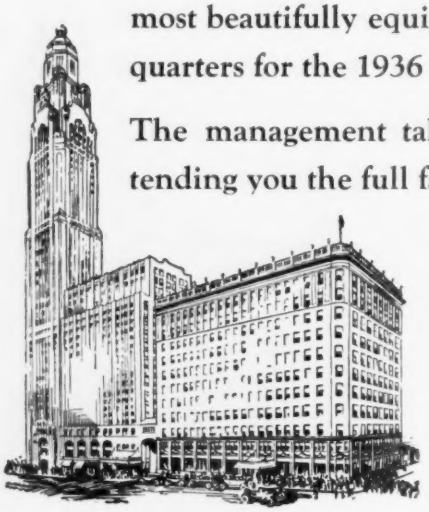

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Clay (Fire)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Clay (German Vallendar)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay Miners
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Potters)
Denver Fire Clay Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Process Equipment)
Bonnot Co.

Clay (Sagger)
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wall Tile)
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co
Spinks Clay Co., H. C.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Colors
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Cornwall Stone (Imported)
Consolidated Feldspar Corp.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Crucibles (Filter, Melting, Ignition)
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Crystolon (Refractory Products)
Norton Co

Cullet, Washing Plants, Incinerators, Crushers
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Drying Machinery
Ferro Enamel Corp.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Enameling Furnaces
Carborundum Co. (*Carboradiant*)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Norton Co.
Porcelain Enamel & Mfg. Co.

Enameling Iron (Sheet)
American Rolling Mill Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co. (*Alundum*)
Pittsburgh Plate Glass Co.

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Exolon (Refractory Products)
Ferro Enamel Corp.
The Exolon Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
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Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

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Carborundum Co.
Denver Fire Clay Co.
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Norton Co.

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Flint
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Paper Makers Importing Co.
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Ferro Enamel Corp.
The Hommel Co., O., Inc.

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Norton Co.

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Consolidated Feldspar Corp.
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Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Fuel Oil Systems and Control, Stokers
Simplex Eng. Co.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

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Glass Equipment
Hartford-Empire Co.
Simpson Foundry & Eng. Co.

Glass Melting Tanks and Furnaces
Simplex Eng. Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Goggles
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Grinding Mills
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Grinding Wheels
Norton Co. (*Alundum Crystolon*)

Hearths
Carborundum Co.
(*Carbofrax* heat treating)
Norton Co. (*Crystolon*)

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.

Iron (Enameling)
American Rolling Mill Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Kaolin
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Kettles of All Kinds
Simpson Foundry & Eng. Co.

Kilns, China (Decorating)
Allied Engineering Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.

Kryolith
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ladles (Cast-iron)
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Leeds (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.

Lehrs
Simpson Foundry & Eng. Co.

Lehrs (Electric or Fuel Heated)
Simplex Eng. Co.

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The Vitro Mfg. Co.

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Drakenfeld & Co., B. F.
The Exolon Co.
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Jungmann & Co., Inc.
Norton Co.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.

Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Manganese (Oxide)
The Roessler & Hasslacher Chemical Co.

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Willson Products, Inc.

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American Rolling Mill Co.

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Bausch & Lomb Optical Co.

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The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Muffles (Furnace)
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Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Mullite (Artificial)
The Exolon Co.

Muriatic Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Nitrates (Cobalt, Sodium)
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The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Norbide (Norton Boron Carbide)
Norton Co.

Olivine
The Roessler & Hasslacher Chemical Co.

Opacifiers
Ceramic Color & Chemical Mfg. Co.
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Jungmann & Co., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
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Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Oxides
Ceramic Color & Chemical Mfg. Co.
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Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Pins
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Potters Supply Co.

Polariscope
Bausch & Lomb Optical Co.
Simpson Foundry & Eng. Co.

Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Porcelain Enamels
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Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
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Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Pot-setting Tools
Simpson Foundry & Eng. Co.

Presses, Side-lever and Bench
Simpson Foundry & Eng. Co.

Producer Glass Plants
Simplex Eng. Co.

Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.

Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation

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Refractories
Carborundum Co
Denver Fire Clay Co.
The Exolon Co.
Norton Co.
Pittsburgh Plate Glass Co.

Refractory Materials
Carborundum Co
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
The Exolon Co.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Titanium Alloy Mfg. Co.

Respirators
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Norton Co.
Potters Supply Co.

Salt Cake
American Potash & Chemical Co.

Saponin
Jungmann & Co., Inc.

Selenite of Sodium
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.

Silica (Fused)
The Exolon Co.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Philadelphia Quartz Co

Silicon Carbide
Carborundum Co.
The Exolon Co.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.
The Exolon Co.

Sillimanite (Synthetic)
The Exolon Co.
Pittsburgh Plate Glass Co.

Slabs (Furnace)
Carborundum Co.
Norton Co.

Smelters
Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O. Inc.
Jungmann & Co., Inc
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Silica Fluoride
Jungmann & Co.

Soot Blowers
Simpson Foundry & Eng. Co.

Special Machines
Simpson Foundry & Eng. Co.

Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Spurs
Potters Supply Co.

Stilts
Potters Supply Co.

Sulfuric Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Talc
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Tanks (Pickle)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.

Tanks for Raw Material Steel or Concrete
Simpson Foundry & Eng. Co.

Tile (Floor)
Norton Co.

Tile (Muffle)
Norton Co.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.

Tile (Wall)
Denver Fire Clay Co.
Ferro Enamel Corp.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Tubes (Insulating)
McDanel Refractory Porcelain Co
Norton Co.

Tubes (Pyrometer)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co
Norton Co.
Pittsburgh Plate Glass Co.

Valves (Butterfly and Reversing)
Simpson Foundry & Eng. Co.

Water Softening Plants
Simplex Eng. Co.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Zinc Oxide
Jungmann & Co., Inc.

Zirconia
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

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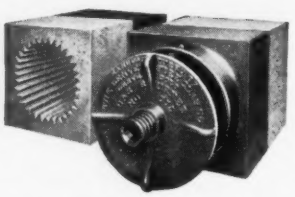

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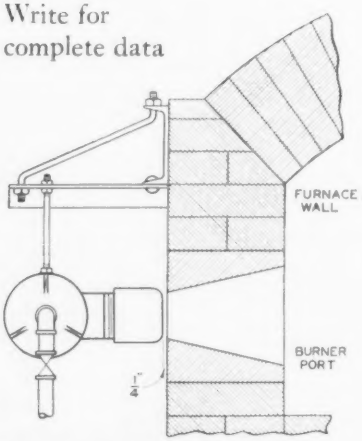

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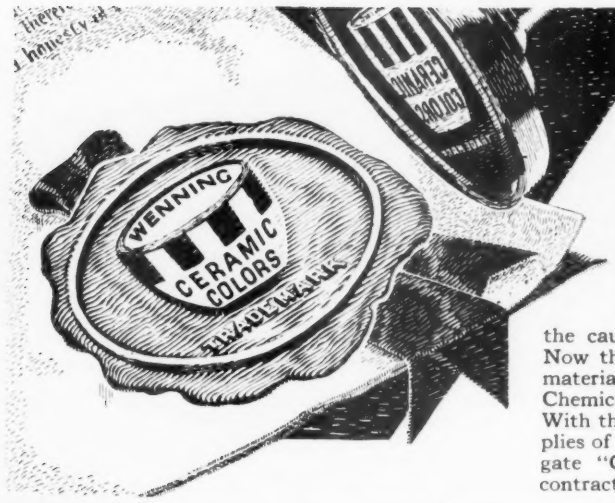

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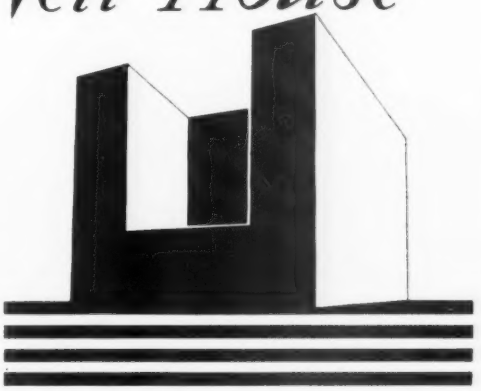
Barium Carbonate	Cobalt Oxide	Nickel Oxide	Titanium Oxide
Black Needle Antimony	Cobalt Sulphate	Nickel Sulphate	Uranium, Orange
Bone Ash	Copper Oxide	Rutile	Uranium, Yellow
Cadmium Carbonate	Iron Oxide	Selenium	Vallendar Clay
Cadmium Sulphide		Sodium Aluminate	

WENNING CERAMIC COLORS

CERAMIC COLOR & CHEMICAL MFG. CO.

NEW BRIGHTON PA.

The Neil House



Columbus, Ohio

American Ceramic Society Headquarters

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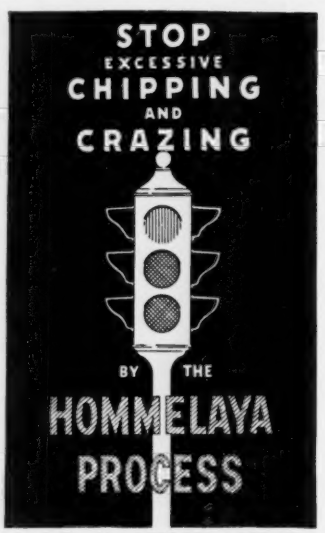

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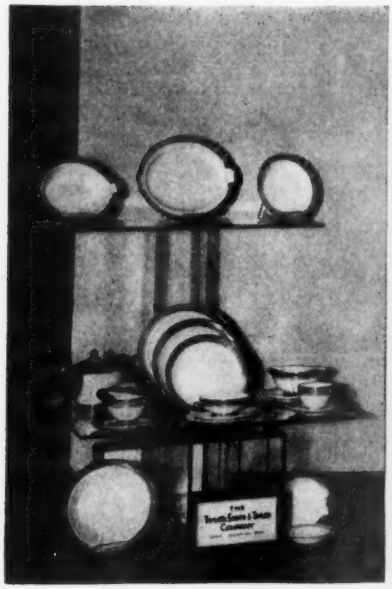

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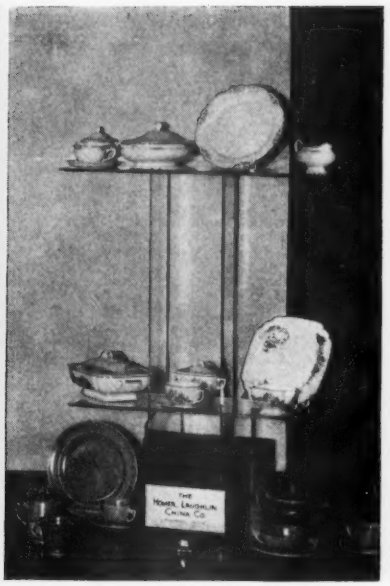

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